ISSN 0006 8241 = Bothalia

Bothalia

A JOURNAL OF BOTANICAL RESEARCH

Vol. 37,2 Oct. 2007

TECHNICAL PUBLICATIONS OF THE SOUTH AFRICAN NATIONAL BIODIVERSITY INSTITUTE PRETORIA

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A JOURNAL OF BOTANICAL RESEARCH

Volume 37,2

Scientific Editor: G. Germishuizen
Technical Editor: B.A. Momberg

SOUTH AFRICAN
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ISSN 0006 8241

Oct. 2007

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A revision of *Ornithogalum* subgenus *Aspasia* section *Aspasia*, the chincherinchees (Hyacinthaceae)

J.C. MANNING*, M. MARTÍNEZ-AZORÍN** and M.B. CRESPO**

Keywords: chincherinchees, Hyacinthaceae, *Ornithogalum* L., South Africa, subgenus *Aspasia* (Salisb.) Oberm., taxonomy

ABSTRACT

The species of *Ornithogalum* L. subgenus *Aspasia* section *Aspasia* are revised. Section *Aspasia* is defined by a rosette of lanceolate to oblong leaves; large, boat-shaped, ± petaloid bracts; moderately-sized white, yellow or orange flowers, sometimes with dark central markings; thin-textured, ellipsoid capsules that are enclosed by and concealed within the persistent, papery perianth; and angular, colliculate to echinulate seeds. Twelve species are recognized in the section, separable into three series based on seed morphology. *O. conicum* is redefined to exclude specimens from the Eastern Cape, which are recognized as *O. synanthifolium*, and *O. conicum* subsp. *strictum* is raised to species status as *O. strictum*. The circumscription of *O. dubium* is expanded to include *O. fimbrimarginatum* and *O. subcoriaceum*, previously distinguished on account of their longer styles. Collections from the Roggeveld Escarpment and Klein Roggeveld that were previously included in *O. fimbrimarginatum* are recognized as the new species *O.* **corticatum** *Mart.-Azorín*, on the basis of their unusual, thick, cartilaginous outer tunics and puberulous adaxial leaf surface. *O. ceresianum* is removed from the synonomy of *O. thyrsoides* and recognized as a distinct species on account of its extensive glossy black tepal markings, winged inner filaments, and glossy black ovary. The poorly known *O. puberulum* is more fully described based on several recent collections, and *O. leeupoortense* is neotypified in the absence of any original type material. *O. rupestre* and *O. multifolium* are regarded as colour forms of the same species, for which *O. rupestre* is the older name. Similarly, *O. roussouwii* is a depauperate, pale form of *O. maculatum* and is thus included in the synonomy of that species. The circumscription of *O. pruinosum* remains unchanged. The species *O. baurii*, *O. diphyllum* and *O. sephtonii* from the Drakensberg Mountains of Eastern Cape and KwaZulu-Natal are excluded from section *Aspasia* on the basis of their turbinate capsules that are exposed by the reflexed tepals. Each species is fully described, with accompanying discussion of variation and relationships, a distribution map, and an illustration.

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INTRODUCTION

Hyacinthaceae, a predominantly Old World family, is distributed throughout Africa and the Mediterranean, extending through central to eastern Asia, with a single, small genus in the Andes Mountains in South America (Speta 1998). Around 400 of an estimated total of 700–900 species are endemic to southern Africa, making it one of the most important geophyte families in southern Africa, exceeded in numbers only by the Iridaceae. Hyacinthaceae are especially numerous in the south-western winter rainfall region, which is one of the main centres of diversity for the family.

Among the more common and conspicuous members here are the large-flowered species of *Ornithoglaum* L. subgenus *Aspasia* (Salisb.) Oberm., known colloquially as chincherinchees, an onomatopoeic sobriquet derived from the sound produced when the stems are rubbed together (Smith 1966). Several species in this group, especially *O. thyrsoides*, are a characteristic part of the southwestern Cape spring, occurring in enormous populations in lowland areas around Cape Town and further north into Namaqualand. Their extreme toxicity (Van Wyk *et al.* 2002) enables them to colonize overgrazed lands with impunity, and their ease of cultivation and long vase-life have made them important horticulturally. Several selections of *O. dubium* and *O. thyrsoides* are available commercially as cut-flowers and further breeding programmes are ongoing. The taxonomy of this group, however, is far from fully understood and several of the species are notoriously difficult to identify.

The southern African species of *Ornithogalum* have been revised three times in the last sixty years, beginning with the work of Leighton (1944, 1945). This review was the first complete regional treatment of the genus since Baker's (1897) account for the *Flora capensis*, with the

apparently significant advantage gained from examination of living material collected in the wild. Leighton, like Baker before her, was impressed by the great variability among populations in the form of the inner filaments, which may be slender and awl-like, lanceolate, with or without small basal expansions, or conspicuously winged. Flower colour is another source of variation, ranging from pure white through various milky-white or buff shades to yellow, orange or reddish orange, with or without small to large dark central markings. Defining her taxa very narrowly, Leighton (1944, 1945) described numerous species to accommodate the different combinations of these characteristics, ultimately recognizing 21 species and many forms in the group (Leighton 1945). With further study, however, it became clear that many of these species represented nothing more than local populations. Obermeyer (1978), who was the first to propose a more formal recognition of the chincherinchees, as the *Aspasiae* group of subgenus *Aspasia*, adopted a much broader view of the species in her monograph on the genus, reducing their number to 10, with two subspecies recognized in *O. conicum*. *Ornithogalum diphyllum* Baker from the KwaZulu-Natal Drakensberg, unaccountably left out of Leighton's treatment, was included as the eleventh member of the group. This treatment was largely followed by Müller-Doblies & Müller-Doblies (1996), who formalized the group as section *Aspasia*. The section was expanded slightly to include two additional species, *O. constrictum* F.M.Leight. and *O. inclusum* F.M.Leight., which had been placed by Obermeyer in the *Hispidaspasiae* group, and was subdivided into two subsections and six series. The species in Obermeyer's *Aspasiae* group were dispersed among four series in two subsections: *Aspasia, Leeupoortensia* U.Müll.-Doblies & D.Müll.-Doblies and *Maculata* U.Müll.-Doblies & D.Müll.-Doblies of subsection *Aspasia,* and series *Ruspestria* U.Müll.-Doblies & D.Müll.-Doblies of subsection *Teretaspasia* U.Müll.-Doblies & D.Müll.-Doblies. A total of 13 species was recognized, two of which, *O. leeupoortense* and *O. roussouwi*, were newly described and another two resuscitated from synonomy.

Despite the relatively high level of taxonomic study to which it has been exposed, the taxonomy of the group remains unclear, and the identification of specimens is often problematical. Although some of the species are well circumscribed and may be identified without much difficulty, the boundaries of others, especially those around *O. dubium*, remain poorly defined. Increased collecting over the past decades has greatly improved our appreciation of the natural variation among wild populations, indicating the need for another review of the species in this group. A comprehensive, illustrated account of the species is presented here for the first time.

It is evident that many of the characters that have traditionally been used to separate species in the group are much more variable than has been realized. This is particularly true of flower colour, the degree of basal expansion of the inner filaments, the length of the style relative to the ovary, and the surface sculpturing of the seeds. Most species are reliably diagnosed by a combination of characters, supplemented with distribution and ecological data. A previously underappreciated character, the size of the seeds, appears to be a useful indicator of relationships among the species. Three seed size classes can be distinguished: large (2.0–3.5 mm long), in *O. conicum, O. corticatum* and *O. synanthifolium*; medium (1–2 mm long), in *O. ceresianum, O. strictum* and *O. thyrsoides*; and small (0.5–1.0 mm long), in the remaining species. The species are arranged in three series according to these size classes.

MATERIALS AND METHODS

This study is based on an examination of dried herbarium specimens as well as living plants studied during extensive field work undertaken thoughout the southwestern Cape. The herbarium specimens studied include the complete collections in BOL, K, NBG and SAM, the types of all names, and selected specimens from PRE. Specimens examined are listed at the end. Seeds were examined with both light and scanning electron microscopy.

TAXONOMY

Ornithogalum L., Species plantarum: 306 (1753). Type: *O. umbellatum* L. (vide Stearn 1983).

Deciduous or rarely evergreen perennials. *Bulb* subterranean or epigeal, subglobose or rarely poorly developed and rootstock rhizomatous, tunics sometimes scale-like or loosely overlapping, usually white but rarely pinkish; outer bulb tunics membranous, papery, or leathery. *Leaves* 1–several, green or dry at flowering, erect or spreading, linear to oblong or filiform, sometimes very succulent, usually glabrous but sometimes pubescent or glandular-pubescent, margins smooth, ciliate, fringed, or hyaline, sheaths sometimes persistent and forming a papery or weakly to strongly fibrous, sometimes horizontally barred sheath around base of stem. *Inflorescence* a several- to many-flowered raceme, sometimes subcorymbose with shortened axis, or secund, usually solitary but sometimes more than one; peduncle rarely papillate; bracts membranous, leafy or petaloid, small or large, not spurred; bracteoles usually lacking but sometimes thread-like and borne on alternate sides of pedicels at base; pedicels short or long. *Flowers* white, yellow, orange, or yellowish green, without darker keels, scented or unscented, sometimes closing at night or more rarely nocturnal, suberect or patent, rotate or campanulate; tepals ovate to narrowly lanceolate, persistent, ± shortly united at base or rarely united into a short tube, spreading to erect, sometimes with tips reflexed. *Stamens* suberect or slightly spreading; filaments free or rarely united below, fused to base of tepals or inserted at top of tube, filiform to lanceolate, all similar or inner usually broader, both whorls or more usually only inner variously expanded or toothed below. *Ovary* ovoid to globose or turbinate, sometimes shortly stipitate; ovules few to many per locule; style vestigial to long, subcylindrical, erect or sometimes slightly deflexed; stigma small and 3-lobed or -angled. *Capsule* fusiform, ovoid to subglobose, ± 3-angled or -lobed, membranous or leathery, enclosed in dry perianth or exposed, dehiscing loculicidally. *Seeds* few to many per chamber, flattened or angled, black, the testa tightly adhering, laevigate, rugulate, papillate or echinate. *Base chromosome number* x = 9.

About 250 species in Africa, Madagascar, Mediterranean, Saudi Arabia and India, mainly in the winter rainfall areas of southern Africa, including ± 40 species in Western Cape, South Africa.

Subgenus **Aspasia** *(Salisb.) Oberm.* in Bothalia 12: 333 (1978). Type: *O. conicum* Jacq.

Section **Aspasia**

Leaves radical, lanceolate to oblong, usually glabrous but sometimes partially or entirely pubescent, margins usually fringed or ciliate. *Inflorescence* sometimes subcorymbose; bracts large, boat-shaped, foliaceous or petaloid, margins entire or ciliate but not denticulate. *Flowers* medium-sized to large, white, yellow or orange, without darker keels but sometimes with dark centre, closing at night, shallowly bowl-shaped; tepals free, ovate, persistent and papery in fruit. *Stamens* free; filaments filiform to lanceolate and all similar or inner broader, both whorls or more usually only inner variously expanded or winged basally. *Ovary* ovoid; style well-developed or vestigial. *Capsule* fusiform or ellipsoid, thin-walled, enclosed and concealed within dry perianth. *Seeds* many per chamber, pyriform, comma-shaped or cuneate, 1–3 mm long, testa papillate or echinulate. *Base chromosome number* x = 6.

Species 12, mainly endemic to the winter rainfall region of the southwestern Cape, with two species extending eastwards to the Eastern Cape.

Key to species

1a Style up to 2.5 mm long; leaves glaucous, margins smooth; flowers yellow to orange, rarely whitish or pinkish, sometimes with dark markings at tips of tepals; bracts brownish apically:
2a Leaves 2–5, narrowly lanceolate to oblong; outer tepals usually with pale or dark marks at tips; flowers larger, tepals 11–25 × 5–14 mm ..... 9. *O. maculatum*
2b Leaves 3–10, subterete or linear-canaliculate; tepals never maculate; flowers smaller, tepals 6–12 × 3.5–5.0 mm ..... 10. *O. rupestre*
1b Style usually more than 2.5 mm long but if shorter then leaf margins ciliate:
3a Leaves 2 or 3, soft-textured, glabrous or pubescent but margins always with soft cilia 1–2 mm long; lower leaf base clasping and inflated; plants from southern Namibia and Richtersveld ..... 12. *O. puberulum*
3b Leaves usually more than 3, ± leathery or subsucculent, margins glabrous to densely ciliate with short, stiff cilia less than 0.7 mm long; plants from South Africa:
4a Robust plants 350–950 mm high, ± evergreen with leaves 200–400 mm long and glabrous or minutely ciliate on margins; lowermost pedicels 15–30 mm long in flower, lengthening up to 35–75 mm in fruit; capsules 12–15 mm long and seeds 2–3 mm long; plants from Eastern Cape, east of Grahamstown ..... 2. *O. synanthifolium*
4b Not as above:
5a Filaments ± monomorphic, filiform to awl-shaped, rarely inner with small basal expansion in lower 1.5 mm; bulbs large, 25–35 mm diam., outer tunics pale and papery; plants restricted to southwestern Cape coastal districts; flowering from late November to January ..... 1. *O. conicum*
5b Filaments ± dimorphic, awl-shaped to lanceolate, inner wider than outer and usually with ± prominent basal expansions:
6a Outer bulb tunics soft-textured or papery, pale grey or whitish; leaves suberect and clasping at base, lanceolate, bright green; seeds 1–2 mm long:
7a Raceme narrowly cylindrical, 70–150 mm long in flower; lowermost pedicels 5–15 mm long at flowering, scarcely elongating in fruit and then 15–25 mm long; flowers rarely with dark centre; inner filaments expanded only in lower third, expansion rhomboidal or inconspicuously toothed; style often deflexed ..... 4. *O. strictum*
7b Raceme conical to subcorymbose, 30–80 mm in flower; lowermost pedicels 14–37 mm long at flowering, elongating up to 20–70 mm long in fruit; flowers with darker centre, although this sometimes small; inner filaments expanded in lower half and clasping ovary, expansions with conspicuous apical wings that often cover top of ovary; style erect:
8a Inner filaments expanded and winged in lower half, outer filaments linear to subulate; flowers usually with small greenish or brownish centre; ovary dull brownish to black ..... 5. *O. thyrsoides*
8b Both inner and outer filaments expanded and winged in lower half, inner more prominently so; flowers with large, dark centre covering lower half of tepals; ovary glossy dark green to black and conspicuously 3-lobed ..... 6. *O. ceresianum*
6b Outer bulb tunics firm-textured and leathery or cartilaginous, grey or blackish; leaves elliptical or shortly lanceolate; seeds usually 0.5–1.0 mm long:
9a Leaf margins glabrous, minutely ciliate or obscurely papillate; plants from drier parts of Northern and Western Cape north of Klawer:
10a Leaves bright green, distichous, falcate, attenuate, as long as or longer than inflorescence; inflorescence usually laterally displaced and thus apparently axillary ..... 11. *O. leeupoortense*
10b Leaves glaucous, rosulate, oblong-lanceolate, leathery, usually less than half as long as inflorescence, margins sometimes crisped ..... 8. *O. pruinosum*
9b Leaf margins densely ciliate; plants from Northern Cape south of Calvinia, Western and Eastern Cape:
11a Leaves shortly pubescent adaxially near apex, withered at flowering; bulbs relatively large, globose, outer tunics cartilaginous or thick and leathery, accumulating in thick layers; flowers white, without dark centre; inner filaments slightly keeled; plants from Roggeveld Escarpment in Northern Cape ..... 3. *O. corticatum*
11b Leaves glabrous except along margins, often still green at flowering; tunics not accumulating in thick layers; flowers orange, yellow, cream-coloured or white, often with dark centre; bracts sometimes ciliate in upper half; plants from Western and Eastern Cape ..... 7. *O. dubium*

Series 1 **Aspasia**

Flowers without dark centre; seeds 2.0–3.5 mm long.

1. **Ornithogalum conicum** *Jacq.*, Collectanea 3: 232 (1791). *O. lacteum* var. *conicum* (Jacq.) Baker: 284 (1873). Type: South Africa, Cape, without precise locality, in Jacq., Icones plantarum rariorum 2, t. 428 (1789b)(icono.!).

O. lacteum Jacq.: 76 (1797). Type: South Africa, Cape, without precise locality, in Jacq., Icones plantarum rariorum 2, t. 434 (1789b)(icono.!).

O. aestivum L.Bolus: 55 (1934). Type: South Africa, [Western Cape], between Malmesbury and Mamre, *L. Bolus s.n. BOL20974* (BOL, holo.!).

Plants 300–600(–900) mm high. *Bulb* subglobose, 25–45 mm diam., flesh sometimes pale pink, outer tunics whitish, papery. *Leaves* spreading or suberect, 5–10, one quarter to one third as long as flowering stem, partially or completely dry at flowering, oblong-lanceolate, 45–100(–120) × 6–25(–30) mm, glabrous but densely ciliate on margins. *Raceme* sub-

corymbose to conical-cylindrical, compact, 30–80 mm long at flowering, elongating to 60–100(–150) mm long in fruit, (11–)15–30(–35)-flowered; lowermost pedicels 10–17 mm long, elongating to 15–28 mm in fruit; bracts petaloid, whitish and papery, ovate, acute or acuminate, usually exceeding pedicels, lowermost 14–20 mm long. *Flowers* white with small greenish yellow centre, unscented or faintly honey-scented; outer tepals ovate-lanceolate, inner obovate, 14–17(–20) × 6–9(–12) mm. *Stamens* half as long as tepals; filaments filiform or subulate, white, 6–8 mm long, rarely inner widened at base. *Ovary* ovoid, 4–5 mm long, greenish yellow but brighter yellow at apex; style white, 2–3 mm long. *Capsule* fusiform to oblong-ovoid, 3-lobed, apiculate, 10–13 mm long. *Seeds* angular and irregularly folded, papillate to echinulate, 2–3 mm long. *Flowering time*: late November or December to mid-January. Figures 1A, 2.

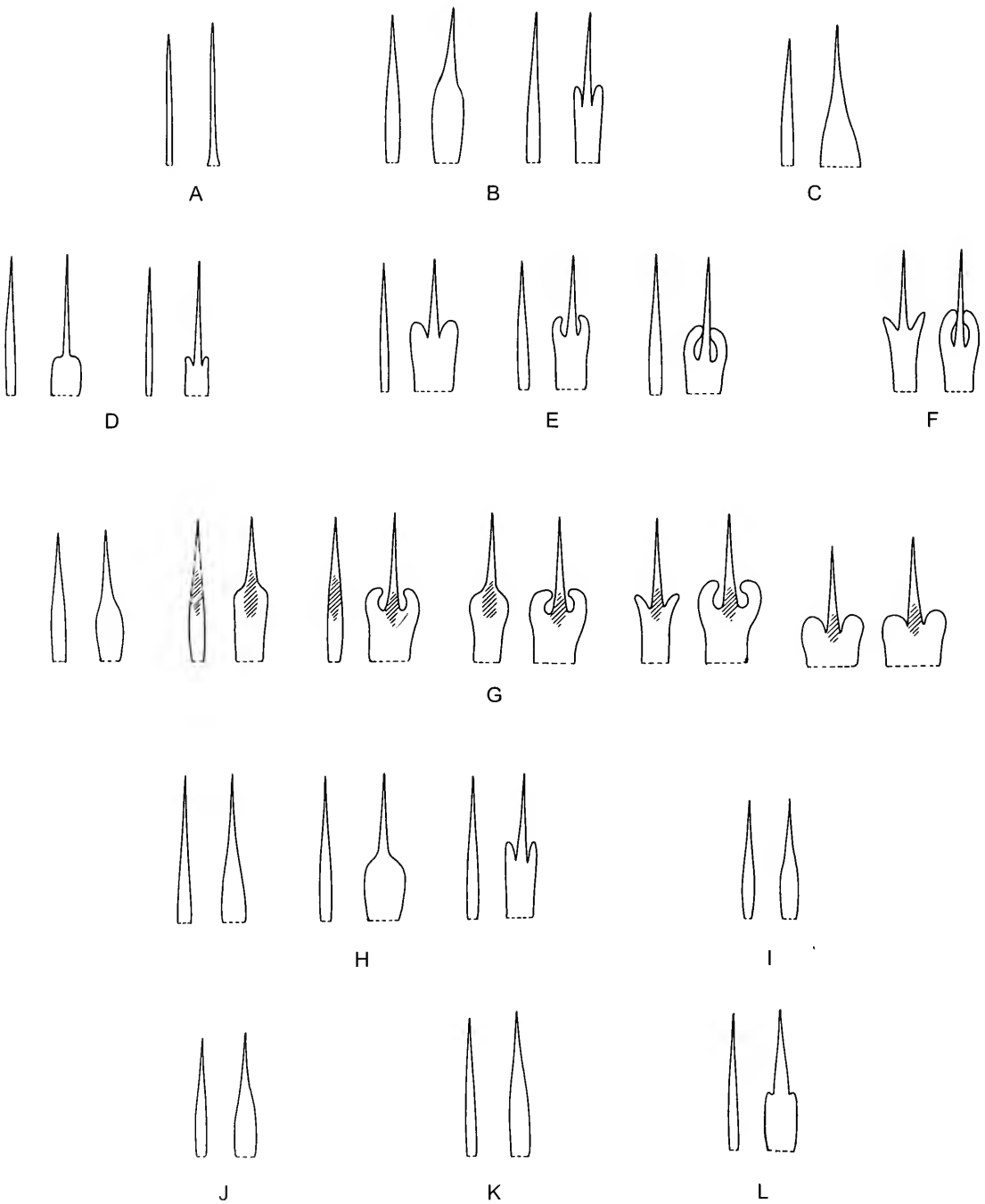

FIGURE 1.—Filament morphology in *Ornithogalum* section *Aspasia*. Filaments are shown in pairs from same flower, outer on left and inner on right. A, *Ornithogalum conicum*; B, *O. synanthifolium*; C, *O. corticatum*; D, *O. strictum*; E, *O. thyrsoides*; F, *O. ceresianum*; G, *O. dubium*; H, *O. pruinosum*; I, *O. maculatum*; J, *O. rupestre*, K, *O. leeupoortense*, L. *O. puberulum*. Not to scale.

FIGURE 2.—*Ornithogalum conicum* Jacq.

Distribution and ecology: restricted to coastal areas in the southwestern Cape, from Graafwater southwards along the west coast to the Cape Peninsula and Gordon's Bay (Figure 3), occurring on coastal limestone pavement, stony hills and granitic outcrops, typically in coarse-grained sandy or gravelly soils but also shale.

Discussion: *Ornithogalum conicum* is a summer-flowering species from coastal areas in the extreme southwestern Cape. It is characterized by its very large bulb, sometimes with pale pink flesh, whitish to light grey, papery tunics, and a rosette of short, densely ciliate leaves less than one third as long as the inflorescence and partially or completely dry at flowering. Both whorls of filaments are typically filiform or awl-shaped, or the inner may rarely be slightly widened at the base but never into the apically lobed, oblong expansions that occur in other species in the group. The species is variable in stature and size with the largest plants, up to 900 mm high, recorded from Paleisheuwel. Plants from the Cape Peninsula are shorter, never more than 500 mm high.

Both *Ornithogalum thyrsoides* and *O. dubium* occur with *O. conicum* on the Cape Peninsula. *O. thyrsoides*,

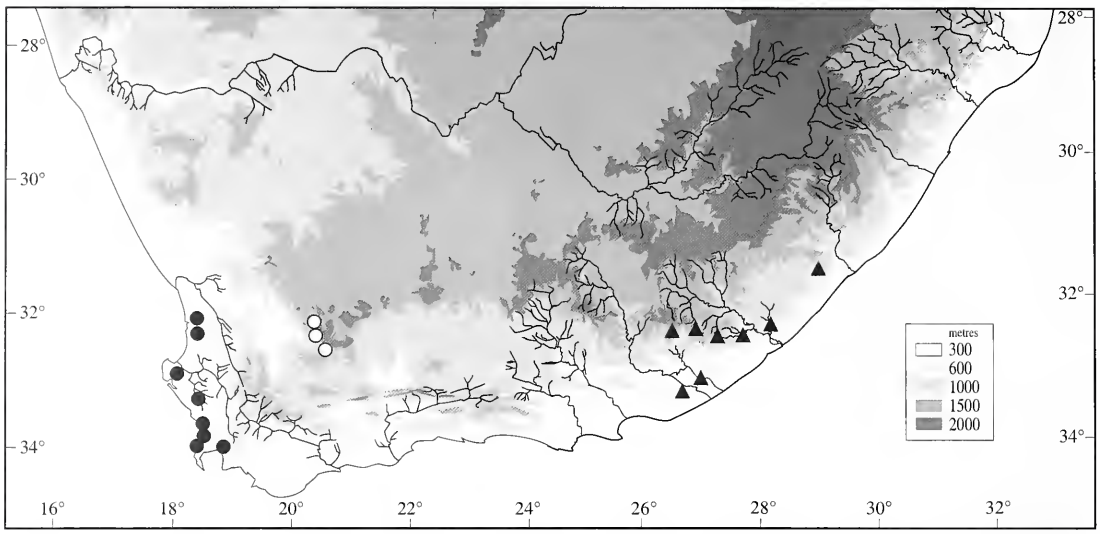

FIGURE 3.—Known distribution of *Ornithogalum conicum*, ●; *O. corticatum*, ○; *O. synanthifolium*, ▲.

which often forms large colonies along road verges and in waste ground, differs in its much smaller bulb, seldom more than 20 mm in diameter, longer, suberect, ± synanthous leaves, and conspicuously winged inner filaments. It also flowers earlier in the season, in September and October, and is in fruit by the time that *O. conicum* begins to bloom in early November. White-flowered forms of *O. dubium* that occur on Table Mountain are distinguished by their smaller bulb with dark tunics, mostly subcorymbose inflorescence, and basally expanded or winged inner filaments. In addition, the ovary in *O. dubium* is typically blackish, unlike the yellow ovary in *O. conicum*, and the seeds are much smaller (± 1 mm vs 2–3 mm long). On the Peninsula, *O. dubium* is restricted to sheltered places on sandstone cliffs, whereas *O. conicum* is found at lower altitudes on exposed granite or shale slopes. The flowers in the populations of *O. conicum* on Lions Head on the Cape Peninsula are open throughout the day from early morning, and are slightly scented, unlike those of *O. dubium*, which only open around mid-morning and lack fragrance.

Although the species has been documented as toxic, the actual identity of the specimens tested is uncertain in view of the much broader circumscription of the species that was current in the past. Given its relatively restricted geographic range, however, it seems more likely that these results were based on tests of *O. strictum* rather than true *O. conicum*.

History: *Ornithogalum conicum* was illustrated and described by Jacquin from cultivated plants that were almost certainly originally collected on the Cape Peninsula, where the species is still found on the slopes of Signal Hill and the foot of Lions Head. At the same time, Jacquin illustrated and named *O. lacteum* but this appears to be nothing more than a luxuriant form with the bases of the inner filaments slightly expanded. This form was reduced to synonomy by Baker (1897), whose concept of *O. conicum*, later followed by Obermeyer (1978), included not only plants from the Eastern Cape with narrow filaments, which are segregated here as *O. synanthifolium*, but also collections from the Olifants River Valley that are treated here as a distinct species *O. strictum*. Both of these taxa have relatively long leaves that are still green at flowering, leading Louisa Bolus to describe *O. aestivum* for plants from the West Coast that produced a rosette of short leaves which were dry and withered by the time that the plants flowered in summer. It is now clear that these populations represent true *O. conicum*, which is more narrowly defined here than in the past.

2. **Ornithogalum synanthifolium** *F.M.Leight.* in Journal of South African Botany 10: 176 (1945). Type: South Africa, [Eastern Cape], King William's Town District, Perie [Pirie] Mtns, *Galpin 2528* (PRE, holo.!).

Plants (200–)350–950 mm high. *Bulb* ovoid, sometimes not well developed, (20–)25–35 mm diam., outer tunics not always persisting but then greyish to blackish, leathery. *Leaves* suberect, 5–11, synanthous, oblong-lanceolate, ± half as long as inflorescence, (150–)200–400 × (8–)10–25(–30) mm, dark green, soft-textured, glabrous or ciliolate on margins. *Raceme* subcorymbose or cylindrical, compact, (50–)70–150 mm long but elongating to 100–150 mm long in fruit, (10–)15–40(–50)-flowered, sometimes two per bulb; lowermost pedicels 15–30 mm long, elongating to 35–72 mm in fruit; bracts pale and papery, ovate, acuminate, lowermost (12–)15–40 mm long, longer or shorter than lower pedicels in flower and shorter in fruit. *Flowers* white; outer tepals ovate-lanceolate, inner obovate-lanceolate, 13–18(–20) × 6–8(–10) mm. *Stamens* half as long as tepals; filaments 5–7 mm long, white, outer linear to narrowly subulate, inner either subulate or expanded and oblong in lower half, rarely winged. *Ovary* ovoid, 3–5 mm long, greenish; style erect, 2–3 mm long. *Capsule* oblong-ovoid to obovoid, 3-lobed, obtuse-apiculate, 12–15 mm long. *Seeds* angular, irregularly folded, 2.5–3.5 mm long, colliculate to papillate, especially along margins. *Chromosomes*: 2n = 12 (De Wet 1957; Pienaar 1963). *Flowering time*: September to January. Figures 1B, 4.

FIGURE 4.—*Ornithogalum synanthifolium* F.M.Leight.

Distribution and ecology: endemic to the Eastern Cape, where it is scattered along the higher ground fringing the coast, from Umtata in the north to Grahamstown in the south (Figure 3), occurring in moist or marshy grassland along streams and in damp valleys, sometimes in dense colonies. The species is typically evergreen and flowers throughout the wet summer season.

Discussion: *Ornithogalum synanthifolium* is typically a large, often evergreen species 350–950 mm high with relatively long leaves, usually at least half as long as the inflorescence. The leaves are soft-textured and bright green, with the margins glabrous or at most ciliolate. The plants produce a subcorymbose to cylindrical raceme of pure white flowers with elongate lower pedicels, 15–30 mm long in flower but lengthening to 35–72 mm in fruit. It is not uncommon for the plants to produce two inflorescences in a single season (e.g. *Pienaar 8*) or for the inflorescence of the previous season to persist alongside that of the current year due to the ± continuous vegetative growth in the species.

The bulb in *O. synanthifolium* may not be well developed as a result of both its evergreen habit and its pref-

erence for moist habitats, and the outer bulb tunics may not persist for the same reasons. When present, the outer tunics are greyish or blackish and somewhat leathery in texture. The inner filaments, like those of most species in the section, are rather variable in shape, ranging from lanceolate to basally expanded or winged, sometimes (*Taylor 4212*) to the degree that they resemble those of *O. thyrsoides*. The large capsules, 12–15 mm long and large seeds, 2–3 mm long, are shared with *O. conicum*. Other members in the section have smaller capsules, and seeds less than 2 mm long.

There is no doubt that the Eastern Cape plants are quite distinct from *O. conicum*, which occurs in seasonally dry situations on the Cape Peninsula and adjacent parts of the southwestern Cape. The climate here is Mediterranean and summer-dry, unlike the summer rainfall climate in which *O. synanthifolium* occurs. True *O. conicum* invariably produces a well-developed, subglobose bulb and a rosette of short, spreading, densely ciliate leaves that are dry and withered at flowering, which takes place in early summer after the rainy season.

In the wild, *Ornithogalum synanthifolium* may be confused with *O. dubium*, the only other species of section *Aspasia* to occur in the Eastern Cape, but the latter is deciduous, grows in more rocky situations, and produces a rosette of spreading leaves that are densely ciliate on the margins and usually shorter than half the length of the inflorescence. The raceme in *O. dubium* is also typically shorter and more densely corymbose than in *O. synanthifolium*, and the seeds are much smaller, ± 1 mm long.

History: *Ornithogalum synanthifolium* has been much misunderstood in the past. The first collection of the species appears to have been made by the Rev. F. Baur near Baziya in Eastern Cape. It was identified as *O. lacteum* Jacq. (now regarded as a synonym of *O. conicum* Jacq.) by Baker (1897) on account of its awl-shaped inner filaments. Another early collection made by Ernest Galpin, a local businessman with an intense interest in botany, probably around the turn of the century, formed the basis of *O. synanthifolium*, which was described by Leighton (1944) for several collections of plants from the Eastern Cape that have the inner filaments expanded at the base but which otherwise closely match those collected by Baur. The latter she retained in *O. lacteum*, albeit as a distinct form restricted to the Eastern Cape.

Ornithogalum synanthifolium was subsequently included in *O. conicum* by Obermeyer (1978), despite the fact that the latter species was otherwise restricted to the extreme southwestern Cape, creating an extraordinary and inexplicable disjunction of some 800 km between the two areas of occurrence. This decision was based largely on the large stature of the plants and their lanceolate or minutely expanded inner filaments. Specimens from the Eastern Cape with more prominently expanded inner filaments were referred to *O. fimbrimarginatum*, here included within *O. dubium*. The inner filaments of *O. synanthifolium*, like so many of the species in this group, are now known to be variable in shape, either lanceolate without basal lobes or with an apically lobed, oblong expansion in the lower portion.

3. **Ornithogalum corticatum** *Mart.-Azorín*, sp. nov.

Planta habitu cum *O. conico* congruens, sed valde differt tunicis bulbi incrassatis corticem fuscum formantibus facile discedentibus, foliis brevibus ad adaxialem apicem pilosis marginibus dense ciliatis per anthesin omnino emarcidis, et staminibus internis filamentis linearibus basi triangularibus carinatis valde dilatatis. Nomen *O. corticatum* a characteribus peculiaribus tunicorum bulbi corticem formatium proveniens.

TYPE.—Northern Cape, 3220 (Sutherland): Klein Roggeveld, Skaapberg, (–DC), 12 November 2005, *M. Martínez-Azorín & J. Manning 96* (NBG, holo.; K, MO, iso.).

Plants (250–)300–450 mm high. *Bulb* depressed-globose, 20–30(–35) mm diam., outer tunics thick, hard and leathery or cartilaginous, pale greyish, brownish or black, accumulating in loose layers. *Leaves* spreading, 5–7, dry at flowering, oblong-lanceolate, up to one quarter as long as inflorescence, 30–60 × (5–)10–15 mm, densely puberulous adaxially in distal half and densely ciliate on margins. *Raceme* conical to cylindrical, compact, 30–90 mm long at flowering, elongating to (35–)70–160 mm in fruit, (6–)16–35-flowered; lowermost pedicels 10–12 mm long, elongating up to 15 mm in fruit; bracts white, petaloid, pale and papery, ovate, acute or acuminate, usually exceeding pedicels, lowermost 13–20 mm long. *Flowers* white; outer tepals ovate-lanceolate, inner tepals obovate-lanceolate, (13–)14–18(–19) × (3–)5–7 mm. *Stamens* ± half as long as tepals; filaments (6–)7.0–8.5 mm long, white, outer subulate, inner triangular and keeled, slightly incurved over ovary. *Ovary* oblong, obtuse or truncate, (3–)4.0–5.5 mm long, greenish below but yellow in upper part; style 3–4 mm long, white. *Capsule* oblong-ovoid, 8–11 mm long, 3-lobed, apiculate. *Seeds* angular-pyriform and irregularly folded, 2.0–2.5 mm long, papillate-echinulate but echinate on margins. *Chromosomes*: 2n = 10 (Pienaar 1963 [as *O. lacteum* forma nov., Sutherland]). *Flowering time*: November. Figures 1C, 5, 6.

Distribution and ecology: endemic to the Roggeveld and Klein Roggeveld near Sutherland in Northern Cape (Figure 3), where it favours heavy clay soils derived from dolerite, growing in open renosterveld shrubland. On the Roggeveld Escarpment, the species may occur in dense colonies numbering thousands of plants that cover large swathes of country. This suggests that it may be toxic to stock. On the more rocky slopes of the Klein Roggeveld, plants tend to be more scattered, sometimes on sandstone pavement along drainage lines.

The old bulb tunics of *Ornithogalum corticatum* are exceptionally firm, accumulating around the bulb in thick, rigid layers. Cartilaginous or thickly matted tunics are a feature of other geophytes from the Roggeveld Escarpment, including *Lachenalia comptonii* (Hyacinthaceae) and *Devia xeromorpha* (Iridaceae). The region experiences extreme climatic conditions through the year, with bitterly cold winters, during which temperatures fall below freezing, contrasting with hot summers when temperatures reach the high thirties, and the thickened covering of the underground parts may act as insulation.

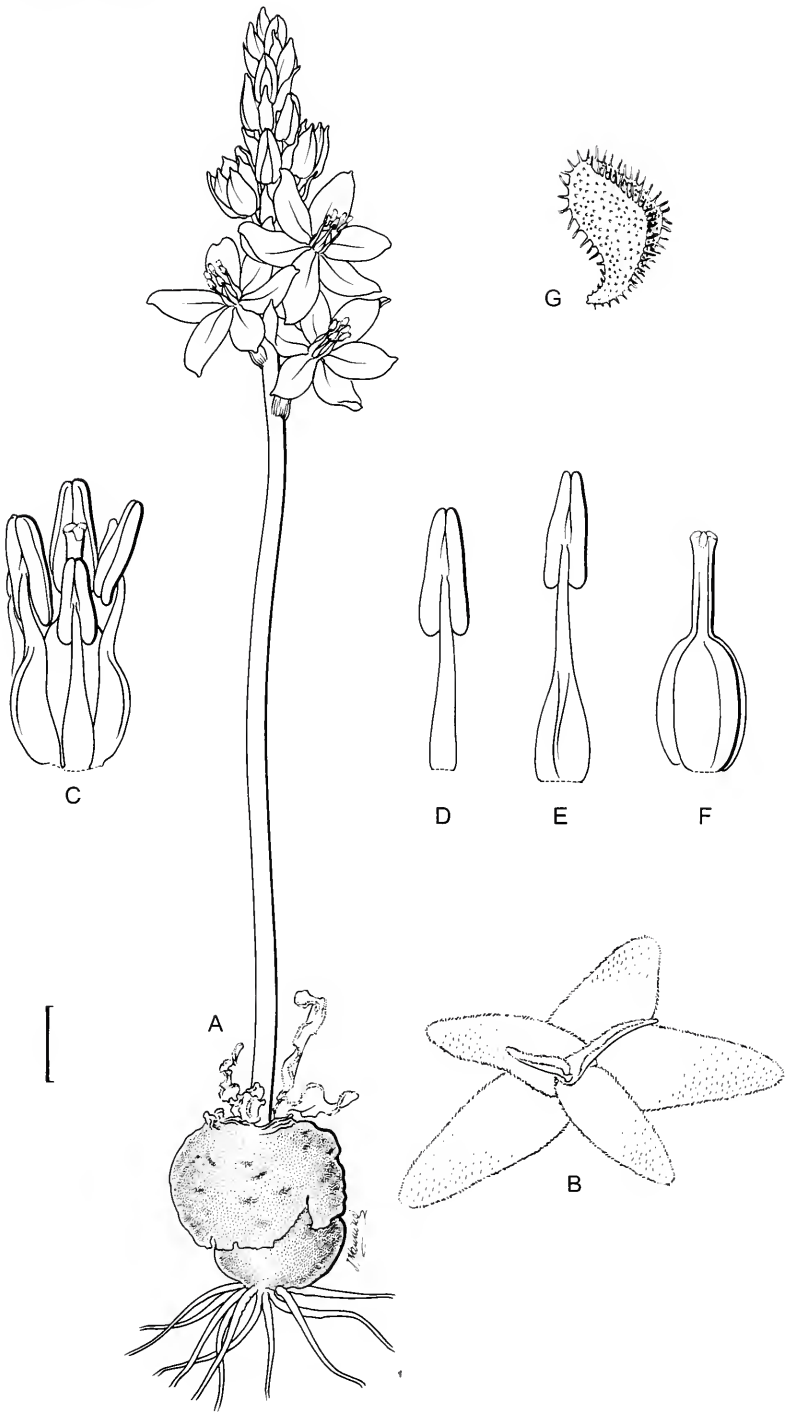

FIGURE 5.—*Ornithogalum corticatum* Mart.-Azorín, *M. Martínez-Azorín & J. Manning 96* (NBG). A, whole plant. B, foliage; C, androecium and gynoecium; D, outer stamen; E, inner stamen; F, gynoecium; G, seed. Scale bar: A, B, 10 mm; C–F, 5 mm; G, 1 mm. Artist: John Manning.

Ornithogalum corticatum flowers in early summer, at which time the leaves are completely withered. Shrinkage of the bulb at this time results in the flesh pulling away from the stiff outer tunics, which form loose, easily detachable layers.

Discussion: *Ornithogalum corticatum* is readily distinguished by its depressed-globose bulb surrounded by firm, cartilaginous tunics, and rosette of short, spreading leaves, less than one quarter the length of the inflorescence, that are shortly and densely hairy on the upper surface in the distal half, and thickly fringed on the margins. These are completely withered at flowering but the pubescence is still visible. The pure white flowers are borne in conical or narrowly cylindrical racemes on short pedicels up to 12 mm long. The relatively large, strongly echinate seeds are also distinctive. Additional support for its recognition as a distinct species comes

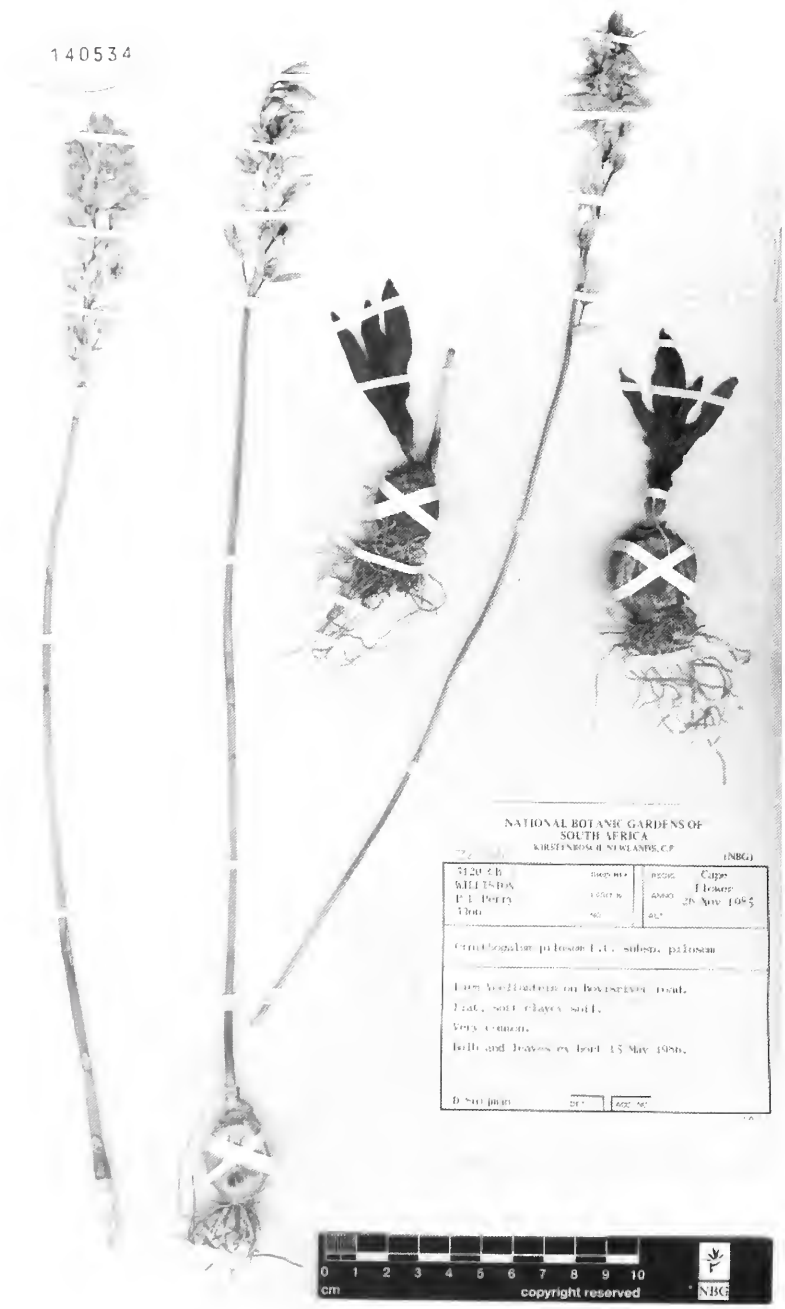

FIGURE 6:—*Ornithogalum corticatum* Mart.-Azorin.

from the cytological studies of Pienaar (1963) and Roos & Pienaar (1966), which identified these plants as a distinctive form of *O. lactemn* (a synonym of *O. conicmn*) with the unusual chromosome number of 2n = 10, other members of the section typically having 2n = 12.

In its narrow raceme *Ornithogalum corticatum* resembles *O. strictum*, with which it has been recorded growing on the Klein Roggeveld, but the tunics in that species are pale and membranous, the leaves are green at flowering, much longer and glabrous, and the inner filaments are oblong in the lower half. The short, densely fringed leaves of *O. corticatum* recall those of *O. conicum* and *O. dubium* but in both these species the leaf surface is glabrous (rarely apically pubescent in *O. dubium*) and the tunics, although leathery, are not as firm-textured as in *O. corticatum*. These two species also differ from *O. corticatum* in details of the flowers. The filaments in *O. conicum* are linear and erect, not curved over the ovary, and *O. dubium* is characterized by a subcorymbose inflorescence with longer, lower pedicels, and inner filaments that are typically expanded and oblong or winged in the lower part, not triangular. The small seeds of *O. dubium*, 0.5–1 mm long vs 2.5 mm also serve to distinguish the species.

History: although first gathered almost seventy years ago by Pauline Bond in 1939, the early collections of *Ornithogalum corticatum* lack the characteristic bulb and were thus referred to *O. conicum* on account of their narrow filaments. Later collections by the horticulturist Harry Hall were assigned to *O. fimbrimarginatum*, now included in *O. dubium*. It is now obvious that they represent a distinct species.

Series 2 **Thyrsoides**

Outer bulb tunics membranous, pale; flowers with or without dark centre; leaves suberect, stem-clasping below; seeds 1.5–2.5 mm long.

4. **Ornithogalum strictum** *L.Bolus* in Journal of Botany, London 71: 72 (1933a). *O. conicum* Jacq. var. *strictum* (L.Bolus) F.M.Leight.: 104 (1944). *O. conicum* Jacq. subsp. *strictum* (L.Bolus) Oberm.: 334 (1978). Type: South Africa, [Northern Cape], Vanrhyn's Pass, September 1931, *P. Ross Frames BOL20072* (BOL, holo.!).

Plants (300–)500–800(–1000) mm high. *Bulb* subglobose, (8–)11–25(–30) mm diam., outer tunics whitish, membranous. *Leaves* suberect to erect, 3–8, synanthous, reaching halfway or more up flowering stem, often to base of raceme, oblong-lanceolate, attenuate, clasping stem in lower part, (80–)130–300(–350) × (6–)8–25(–35) mm, glabrous but slightly to densely ciliate along margins. *Raceme* narrowly conical, compact, (50–)70–150 mm long at flowering, elongating to (70–)100–200(–300) mm in fruit, (9–)15–40(–65)-flowered; lowermost pedicels 5–14 mm long, elongating to 9–20 mm in fruit; bracts petaloid, pale and papery, ovate, acute or acuminate, usually exceeding pedicels, lowermost 15–30(–45) mm long. *Perianth* pure white, rarely with small brownish stain in centre; outer tepals ovate-lanceolate, inner obovate, (15–)16–22(–25) × 6–10 mm. *Stamens* half as long as tepals; filaments filiform to subulate, (5–)7–10 mm long, white, inner usually with square basal expansion in lower $^1/_4$–$^1/_3$, sometimes bilobed or slightly winged above. *Ovary* oblong, 3–6 mm long, truncate, 3-lobed, usually yellow or greenish yellow, rarely dark greenish; style white, often deflexed, 3–6 mm long. *Capsule* fusiform to oblong-ovoid, apiculate, 10–12 mm long. *Seeds* angular-pyriform and irregularly folded, 1.5–2.0 mm long, colliculate to rugulose but echinulate on margins. *Chromosomes*: 2n = 12 (Pienaar 1963 [as *O. conicum* var. *strictum*]). *Flowering time*: September–November. Figures 1D, 7.

Distribution and ecology: common along the Bokkeveld Mountains around Nieuwoudtville and through the Olifants River Valley, with outlying populations at the foot of the Piketberg and in the Ceres Valley in the south, and scattered collections from the Roggeveld and Klein Roggeveld in the east, from 100–800 m above sea level (Figure 8). The species occurs mainly on fine-grained clay or loam, typically on moist slopes or in drainage lines or vleis, where it can occur in large concentrations. On the Klein Roggeveld the species grows in washes along seasonal streams.

Ornithogalum strictum is the common white chincherinchee in the Olifants River Valley, sometimes forming large swathes in seasonal vleis on the valley bottom.

Discussion: *Ornithogalum strictum* is recognized by its thin-textured, pale grey or whitish bulb tunics, long, erect leaves that often reach to the base of the raceme and are green at flowering, and by the narrowly conical raceme with short lower pedicels, typically less than 15 mm long. The flowers are usually pure white, although populations near Citrusdal may include individuals with a brownish centre. The ovary is mostly yellow or yellowish green and the style is typically deflexed in a highly characteristic manner unique to the species. The inner filaments are usually widened in the lower third into an oblong expansion, sometimes bilobed above but not distinctly winged. As in most species of section *Aspasia*, *O. strictum* shows some variation in the degree of expansion of the inner filaments. Plants from the Bokkeveld Escarpment have the inner filaments invariably expanded in the basal third but populations from further south, in the Olifants River Valley and around the Piketberg, may have almost linear or subulate inner filaments.

Ornithogalum strictum resembles *O. thyrsoides* in its pale outer tunics, slender leaves clasping the base of the stem, and expanded inner filaments, and both seem to occupy similar, seasonally moist habitats. *O. thyrsoides* can usually be distinguished by its subcorymbose to broadly cylindrical inflorescence with longer lower pedicels, especially in fruit, and inner filaments that are broadly expanded in the lower half (not third) and always conspicuously winged, with the wings curved over the ovary, which is typically dark greenish or blackish.

The distinction between the two is not always clear, however, especially in the Olifants River Valley, where occasional plants with the narrowly cylindrical raceme of *Ornithogalum strictum* have winged inner filaments like those of *O. thyrsoides*. A similar situation arises further north in Namaqualand. An alternative treatment would be to regard *O. strictum* as the northern subspecies of *O. thyrsoides* but intermediate types are rare and we prefer to maintain the two taxa as separate species, especially in view of the unusual declinate style that appears to characterize *O. strictum*.

History: described by Louisa Bolus in 1933 from plants collected on Vanrhyn's Pass on the Bokkeveld Escarpment, *Ornithogalum strictum* was included in *O. conicum* by subsequent authors (Leighton 1944; Obermeyer 1978), although it continued to be distinguished at an infraspecific level by its slender, narrowly conical raceme. The decision to include it in *O. conicum* was made on account of the relatively weakly expanded inner filaments, which are quite unlike the broadly winged filaments that are diagnostic of *O. thyrsoides*. It is now clear that *O. conicum*, with its large bulb, short, densely ciliate leaves, and larger seeds, is quite a different species, and on vegetative and seed characters it appears that *O. strictum* is actually more closely allied to *O. thyrsoides*.

5. **Ornithogalum thyrsoides** *Jacq.*, Hortus botanicus vindobonensis 3: 17 (1776). Type: South Africa, Cape, without precise locality, in Jacq., Hortus botanicus vindobonensis 3: t. 28 (icono.!).

O. coarctatum Jacq. 2: t. 435 (1795). Type: South Africa, Cape, without precise locality, in Jacq., Icones plantarum rariorum 3: t. 435. (icono.!).

FIGURE 7.—*Ornithogalum strictum* L.Bolus.

O. bicolor Haw.: 177 (1803). Type: South Africa, [Western Cape], Cape of Good Hope, ex Whitley's Nursery (type not traced).

O. hermannii F.M.Leight.: 71 (1933b). Type: South Africa, [Western Cape], Clanwilliam Dist., 9 miles [14.4 km] N of Citrusdal, 1 October 1932, *T.M. Salter 2806* (BOL, holo.!; K, iso.!).

Plants (110–)150–600(–700) mm high. *Bulb* subglobose, comparatively small, 7–20(–23) mm diam., outer tunics usually whitish, sometimes greyish or brownish, membranous. *Leaves* erect or suberect, 3–7(–9), synanthous or withered at anthesis, narrowly oblong-lanceolate, attenuate, 100–300(–380) × 5–20(–25) mm, clasping stem below, glabrous but minutely to densely ciliate on margin. *Raceme* conical-cylindrical to subcorymbose, (40–)45–80(–95) mm long at flowering, elongating to 80–150(–200) mm in fruit, (6–)8–40-flowered, sometimes two per bulb; lowermost pedicels (8–)14–24 mm long, elongating to (8–)15–50(–70) mm in fruit; bracts pale, ovate, acute or acuminate, shorter or longer than pedicels, lowermost 15–40(–50) mm long. *Flowers* milky white or pure white, usually with small greenish or brownish centre; outer tepals ovate-lanceolate, inner obovate, 12–25(–27) × (6–)8–12(–15) mm. *Stamens* half as long as tepals, sometimes shorter; filaments (4–)5–8(–11) mm long, white, outer subulate and slightly broader at base, inner greatly expanded in lower two thirds

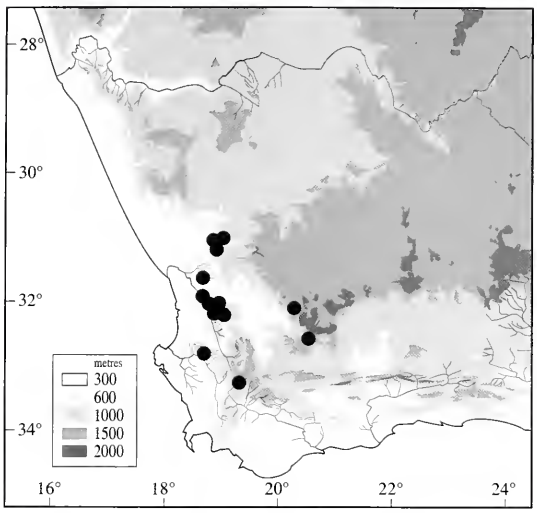

FIGURE 8.—Known distribution of *Ornithogalum strictum*.

with paired, wing-like outgrowths curved inwards over ovary. *Ovary* ovoid, obtuse, 3–6 mm long, grey, green or brown; style erect, 2.5–4.0 mm long, white or pale greenish. *Capsule* fusiform to oblong-ovoid, (9–)10–15(16) mm long, 3-lobed, apiculate. *Seeds* ovoid-angular and irregularly folded, 1.5–2.0 mm long, rugulose or colliculate and then echinulate on margins. *Chromosomes*: 2n = 12 (Neves 1953; De Wet 1957; Pienaar 1963). *Flowering time*: late September to early November. Figures 1E, 9.

Distribution and ecology: widespread through the southwestern Cape, from Bredasdorp in the south to Vanrhynsdorp on the West Coast, with outlying populations recorded from further north on the higher ground in central Namaqualand, between Garies and Steinkopf (Figure 10). The species is typically found at lower altitudes and has not been recorded from the Bokkeveld, Cedarberg or Cold Bokkeveld Mountain ranges. We have not encountered it in the Warm Bokkeveld either, and the only known collection from Ceres (*Walters 904*) probably refers to the general region and not the town itself. The species is common on shale or loamy soils, especially in seasonally moist sites and ditches along roadsides. It appears to flourish under slight disturbance or overgrazing, and in such conditions may occur in dense colonies numbering hundreds or thousands of plants.

Ornithogalum thyrsoides is the most commonly encountered species in the southwestern Cape, especially along the west coast between Piketberg and Gordon's Bay, and is the original florists' chincherinchee.

It is known to be highly toxic to stock (Van Wyk *et al.* 2002), which may contribute to its rather weedy propensity. The toxic compound in the plants has been identified as prasinode G, a steroid glycoside (Van Wyk *et al.* 2002).

Discussion: *Ornithogalum thyrsoides* is characterized by its relatively small bulb with pale, membranous outer tunics, and slender, erect leaves that clasp the base of the stem. The outer filaments are slender and awl-shaped but the inner filaments are conspicuously expanded in the lower two-thirds, the expansions with prominent apical wings that are curved over the dark greyish to brownish ovary. *O. thyrsoides* is usually readily distinguished from other species, including *O. conicum*, by the combination of thin-textured, pale tunics and winged filaments but may be difficult to differentiate from *O. strictum* in the Olifants River Valley where the two species co-occur. *O. strictum* typically has a longer, narrower raceme, inner filaments that are only expanded in the lower third and not winged, and an ovary that is usually yellow or pale greenish with a deflexed style.

Further south, in the Swartland and Boland, *Ornithogalum thyrsoides* occurs with *O. dubium* but that species is distinguished by its black outer tunics, shorter, more densely cilate leaves and often shorter style. In addition, the filaments in *O. dubium* are often thicker-textured, and the outer may also be somewhat expanded rather than awl-shaped. Around Tulbagh, where the two species co-occur, *O. thyrsoides* favours moister, loamy soils while *O. dubium* prefers drier, stonier situations. Careful examination of mixed populations has failed to reveal a single hybrid plant. In the Warm Bokkeveld around Ceres, *O. thyrsoides* is replaced by *O. ceresianum*. Although vegetatively similar and occupying similar habitats, *O. ceresianum* is recognized by the very large, dark centre to the flower, covering the lower half of the tepals, and by having all six filaments winged, not just the inner three.

The species is rather variable in the shape of the inflorescence, which may range from narrowly cylindrical to subcorymbose, and in the size of the flowers. Many of these forms were accorded species status by Leighton (1944) but we prefer to treat them as part of the normal variation of the species. Among the more distinctive local forms are those from Langebaan and Saldanha (*Boucher 6476, 6477*; *Craven 175*), which are anomalous in their dark, brownish tunics. A particularly attractive form, with dense, subcorymbose racemes of flowers with distinctive, brownish centres occurs around Darling and Saldanha. In the Olifants River Valley some individuals have unusually long, narrowly cylindrical racemes (e.g. *Boucher 2617*), thus resembling *O. strictum*. The dark ovaries or bases to the tepals, strongly winged inner filaments, and erect styles, however, are more consistent with *O. thyrsoides*. Further north, populations between Klawer and Kamieskroon are robust, with arcuate, rather woody pedicels in fruit. Finally, *Barker 3332* from Aries Kraal near Elgin includes plants with unusually short styles and scarcely winged inner filaments. Although resembling *O. dubium* in these features, the long, pointed leaves and small bulbs of these plants are more consistent with *O. thyrsoides*. It is possible that occasional hybridization may be the origin of some of these anomalous plants.

History: *Ornithogalum thyrsoides* was among the earliest species in the genus to be described from southern Africa and the first in section *Aspasia*. The winged inner filaments led Baker (1897) to conflate the species with *O. dubium*, and even Obermeyer (1978) was misled into treating *O. gilgianum* from Bainskloof (here included in *O. dubium*) as a synonym despite its dark tunics. Since the revision of Leighton (1944), however, the species has mostly been correctly understood.

FIGURE 9.—*Ornithogalum thyrsoides* Jacq.

6. **Ornithogalum ceresianum** *F.M.Leight.* in Journal of Botany, London 71: 72 (1933a). Type: South Africa, [Western Cape], near Ceres, November 1931, *Cook sub Nat.Bot.Gard.1756/25* (BOL, holo.!; K, iso.!).

Plants 200–350 mm high. *Bulb* subglobose, (11–)13–20 mm diam., outer tunics whitish, sometimes brownish grey, somewhat leathery or membranous. *Leaves* 3–7, suberect, more than half as long as inflorescence, sometimes reaching to base of raceme, partially or mostly dry at flowering, oblong-lanceolate, 40–90(120) × 7–14(–18) mm, attenuate, clasping stem in lower part, glabrous. *Raceme* subcorymbose to conical, compact, 30–80 mm long at flowering, elongating to 60–100 mm long in fruit, 7–15(–20)-flowered, sometimes two per bulb; lowermost pedicels 27–37 mm long, elongating to 30–40 mm in fruit; bracts pale brownish and papery, ovate, acute or acuminate, lowermost 20–26 mm long, shorter than lowermost pedicels. *Flowers* creamy white with large, dark olive green central stain covering basal third of tepals, outer tepals ovate-lanceolate, inner obovate lanceolate, 16–21 × 7–11 mm. *Stamens* half as

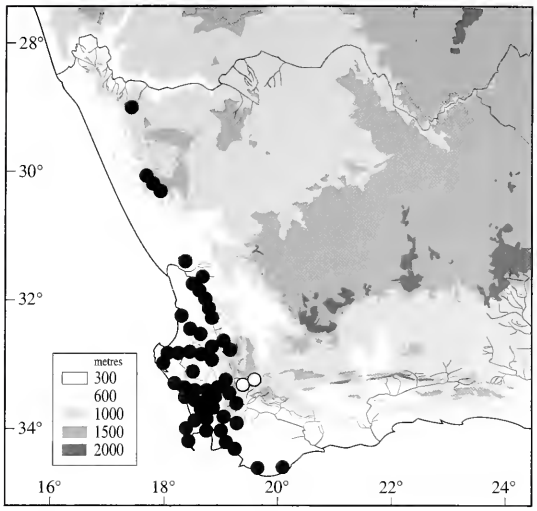

FIGURE 10.—Known distribution of *Ornithogalum thyrsoides*, ●; *O. ceresianum*, ○.

long as tepals; filaments 7–9 mm long, white, expanded and winged in lower two thirds, outer with shorter narrow wings, inner with longer wings. *Ovary* obovoid, 4–6 mm long, truncate, 3-lobed, glossy dark green to black in upper half, greyish below; style erect, 3.0–3.5 mm long, black. *Capsule* oblong-ellipsoid, 3-lobed, 10–12 mm long. *Seeds* angular-tetrahedral, 1.5–2.0 mm long, rugulose. *Chromosomes*: 2n = 12 (Pienaar 1963). *Flowering time:* October, rarely November. Figures 1F, 11.

Distribution and ecology: a local endemic of the Warm Bokkeveld around the town of Ceres (Figure 10), where it occurs in loamy soils in seasonally moist vleis and along seasonal streams, usually in dense colonies.

Discussion: although vegetatively similar to *Ornithogalum thyrsoides* in its small bulb with pale, membranous tunics and slender, suberect leaves clasping the stem at the base, *O. ceresianum* is distinguished by the large, dark olive central eye that covers the basal third of the tepals, the glossy black ovary, and by having all six filaments expanded and winged in the lower two thirds. The inner filaments are more broadly winged than the outer and in some individuals may be petaloid with a dark base. In *O. thyrsoides* the outer filaments are at most slightly expanded, the dark centre of the flower is much smaller, covering no more than the base of the tepals, and the ovary is ovoid and matt. In addition the racemes are typically longer, with the lower pedicels shorter in fruit.

This striking species deserves to be in cultivation, and there is little doubt that it can be as easily grown as *Ornithogalum thyrsoides*.

History: first collected in the early years of the twentieth century, *Ornithogalum ceresianum* was described some twenty years later by Frances Leighton (1933a) but was subsequently treated as merely an unusual form of *O. thyrsoides* (Obermeyer 1978). Having seen the taxon in the wild, however, we are convinced that it is sufficiently distinct from *O. thyrsoides* in several respects to warrant recognition as a distinct species.

Series 3 **Maculata**

Outer bulb tunics often dark; flowers white, yellow or orange, with or without dark centre; seeds 0.5–1.0 mm long.

7. **Ornithogalum dubium** *Houtt.* in Natuurlijke historie 2,12: 309, t. 82, fig.3 (1780). Type: South Africa, Cape of Good Hope, without precise locality, in Houttuyn herbarium (G, holo.–photo.!).

O. flavissimum Jacq.: t. 436 (1789b). Type: South Africa, without precise locality, in Jacq., Icones plantarum rariorum 2: t. 436 (icono.!).

O. flavescens Jacq.: 20, t. 437 (1789b). Type: South Africa, without precise locality, in Jacq., Icones plantarum rariorum 2: t. 437 (icono.!).

O. miniatum Jacq.: t. 438 (1789b). Type: South Africa, without precise locality, in Jacq., Icones plantarum rariorum 2: t. 438 (icono.!).

O. aureum Curtis: t. 190 (1792). Type: South Africa, without precise locality, in Curtis's Botanical Magazine: t. 190 (icono.!).

O. vandermerwei Barnes: 14 (1931). *O. miniatum* var. *vandermerwei* (Barnes) F.M.Leight.: 89 (1944). Type: South Africa, [Western Cape], 8 miles [12.8 km] from Bonnievale on road to Swellendam, 8 October 1929, *N.J.S. van der Merwe BOL1814/29* (BOL, holo.!).

O. vandermerwei Barnes var. *album* Barnes: 14 (1931). Type: South Africa, [Western Cape], between Worcester and Robertson, October 1930, *Hurling & McNeil BOL19296* (BOL, holo.!).

O. fergusoniae L.Bolus: 57 (1932). Type: South Africa, [Western Cape], near Still Bay, November–December 1931, *E. Ferguson NBG45/31* (BOL!, lecto., designated in Obermeyer 1978; K, isolecto.!).

O. brownleei F.M.Leight.: 62 (1933b). Type: South Africa, Eastern Cape, King William's Town Div., Middledrift, without date, *Brownlee BOL20366* (BOL, holo.!).

O. leipoldtii L.Bolus: 71 (1933a). Type: South Africa, [Western Cape], Clanwilliam Div., between Klawer and Clanwilliam, Olifants River Valley, April 1929, *C.L. Leipoldt BOL19941* (BOL, holo.!; K, iso.!).

O. subcoriaceum L.Bolus: 55 (1934), syn. nov. Type: South Africa, [Northern Cape], near Nieuwoudtville, *L. Bolus BOL20090* (BOL, holo.!).

O. alticolum F.M.Leight.: 93 (1944). Type: South Africa, [Western Cape], Paarl Div., top of Dutoitskloof, without date, *Pillans 8384* (BOL, holo.!).

O. pillansii F.M.Leight.: 96 (1944). Type: South Africa, [Western Cape], Piketberg Div., near Het Kruis, 29 September 1943, *Leighton 134* (BOL, holo.!; K!, PRE, iso.).

O. fimbrimarginatum F.M.Leight.: 105 (1944), syn. nov. Type: South Africa, [Western Cape], Montague, Whitehill Ridge, 25 October 1944, *F.M. Leighton 273* (BOL, holo.!; K, iso.!).

O. citrinum Schltr. ex Poelln.: 22 (1944). Type: South Africa, [Western Cape], Genadendal, without date, *Schlechter 9797* (B, holo.; GRA, K!, PRE, iso.).

O. gilgianum Schltr. ex Poelln.: 23 (1944), syn. nov. Type: South Africa, [Western Cape] Bainskloof, 3000′ [915 m], 12 November 1896, without date, *Schlechter 9131* (B, holo.; BOL!, K!, PRE, iso.).

O. perpulchrum Schltr. ex Poelln.: 24 (1944), syn nov. Type: South Africa, [Western Cape], Rietfonteinpoort (10 miles [16 km] SSE of Elim), 10 December 1896, *Schlechter 9681* (B, holo.; BM, BTU, GRA, K!, NSW, PRE, S, Z, iso.).

Plants (50–)100–450(–650) mm high. *Bulb* subglobose, (7–)10–20(–25) mm diam., outer tunics leathery to cartilaginous, dark brown or blackish. *Leaves* spreading, rarely suberect, (2)3–7(–9), green or dry at anthe-

FIGURE 11.—*Ornithogalum ceresianum* F.M.Leight.

sis, oblong-lanceolate to ovate, (20–)25–160(–200) × (3–)5–18(–20) mm, obtuse to acute, glabrous but thinly to densely ciliate on margins, rarely ciliae extending onto adaxial surface near apex and blade thus puberulous apically. *Raceme* corymbose to subcorymbose, rarely shortly cylindrical, (15–)20–60(–100) mm long at flowering, elongating to 30–100(–150) mm in fruit, (2)3–20(–30)-flowered; lowermost pedicels (8–)10–35 mm long, elongating to (12–)15–45(–55) mm in fruit; bracts greenish or whitish but dry and brown apically, ovate, acute or acuminate, usually shorter than pedicels, sometimes ciliate along margins in upper third or near apex, lowermost (6–)10–30(–35) mm long. *Flowers* orange, yellow, cream-coloured or white with a brownish or greenish centre, or plain orange or yellow; outer tepals ovate-lanceolate, inner obovate, (7–)10–20(–23) × (3–)5–11(–13) mm. *Stamens* one third to half as long as tepals; filaments (3.5–)4.0–6.0(7.0) mm long, usually with brown or blackish stain in middle, or upper part orange, yellow or brownish, sometimes entirely white, often thick-textured, usually outer subulate and inner broader and winged but sometimes all subulate to trian-

FIGURE 12.—*Ornithogalum dubium* Houtt.

gular or variously expanded and winged. *Ovary* ovoid, (2.5–)3.0–6.0 mm long, blue-greyish, greenish or yellow, usually narrowing into style, sometimes truncate; style short and thick or longer and slender, (1.5–)2.0–3.5(–4.0) mm long, white, yellow or blackish, erect. *Capsule* fusiform to oblong-ovoid, (5–)8–15 mm long, 3-lobed, apiculate. *Seeds* angular-pyriform, 0.5–1.0 mm long, echinulate to long-echinate. *Chromosomes*: 2n = 10, 12 (De Wet 1957), 12, 12 + 5B, (18, 24) (Pienaar 1963). *Flowering time*: September–November at lower altitudes but December–January at higher altitudes. Figures 1G, 12.

Distribution and ecology: widespread through the southwestern and southern Cape, from the Bokkeveld escarpment southwards to the Cape Peninsula and thence eastwards along the coast and through the Little Karoo as far as Kentani and Stutterheim in the Eastern Cape (Figure 13). The species typically grows on stony flats or rocky slopes in pockets of shallow soil or humus in rock crevices, sometimes along rocky stream banks, in a wide variety of soils, from fine-grained clay to limestone or sandstone and in a range of vegetation types, including renosterveld and fynbos.

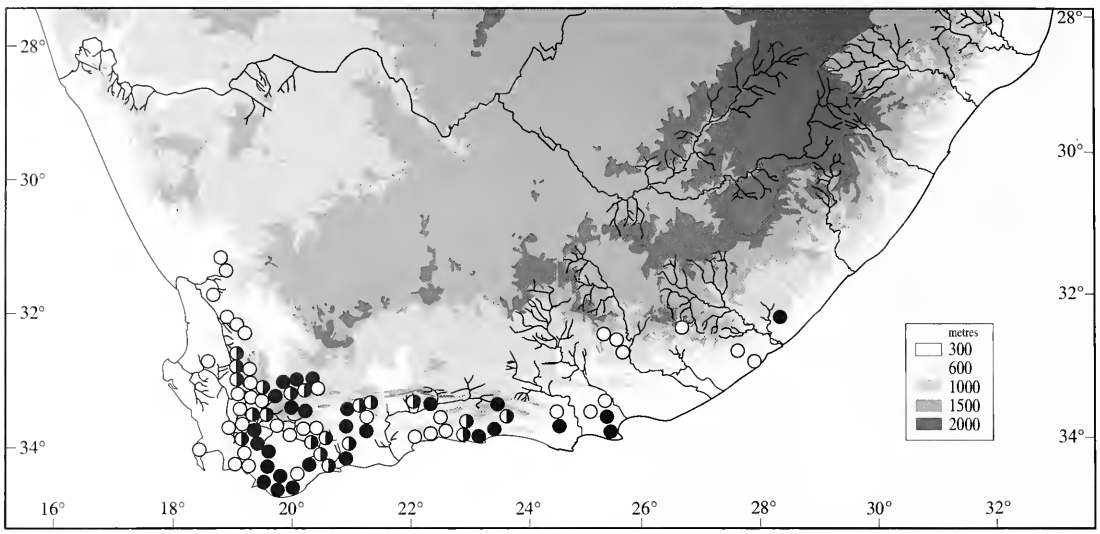

FIGURE 13.—Known distribution of *Ornithogalum dubium*: white-flowered populations, ○; yellow-flowered populations, ●; yellow- and orange-flowered populations, ◑.

Discussion: as circumscribed here, *Ornithogalum dubium* is defined by the firm-textured, dark brown to black bulb tunics, spreading, rather blunt leaves, seldom up to half as long as the infloresence and typically densely ciliate on the margin, and corymbose to subcorymbose raceme of white, yellow or orange flowers, usually with a dark centre. The filaments are at least partially concolorous with the tepals, often with a dark zone in the middle or upper part, and the dark-coloured ovary typically narrows into the style, which may be shorter than or subequal to the ovary. The seeds are minute, 0.5–1.0 mm long, and echinulate. Similar small seeds are characteristic of all members of series *Maculata*.

Yellow- or orange-flowered plants with dark outer bulb tunics and ciliate leaves are readily assigned to *Ornithogalum dubium* but white-flowered individuals may pose some problems. The dark tunics, relatively short, spreading leaves and corymbose inflorescence serve to distinguish such plants from *O. thyrsoides* and *O. strictum*, which also have larger seeds, 1.5–2 mm long. *O. pruinosum*, from further north in Namaqualand, has similar dark tunics and small seeds but the leaves are distinctly glacous and usually glabrous or minutely puberulous on the margins. *O. corticatum* from the Roggeveld Escarpment is distinguished by its thick, almost corky bulb tunics, leaves that are distinctly pubescent on the upper surface near the ends, plain white tepals and filaments, and yellow ovary. On the Cape Peninsula, *O. conicum* is recognized by its large bulb and linear-filiform filaments and larger seeds. In the Eastern Cape, white-flowered *O. dubium* is distinguished from *O. synanthifolium* by its deciduous habit, shorter leaves with ciliate margins, subcorymbose inflorescence and much smaller seeds (0.5–1.0 mm vs 2–3 mm).

Ornithogalum dubium is easily the most variable species in the section, displaying almost the entire range of flower colours and filament forms found among the species of sect. *Aspasia*. Populations are often constant in flower colour, comprising plants that are either white-flowered, or yellow- to orange-flowered, sometimes with less than one kilometre separating populations of different colours. However, varicoloured populations are known from throughout the range of the species. We have seen a good example of such a population at Hottentotskloof, east of Ceres, comprising individuals displaying the entire range of different flower colours, from orange and yellow through cream-coloured to white with brownish centres.

Plants that match the type of *Ornithogalum dubium* and from which the original collections are most likely to have been made, occur around the town of Tulbagh at the head of the Breede River, on the original track into the interior. These populations have bright yellow or orange flowers and orange filaments, the inner expanded at the base and apically pointed but not winged, and short styles. Populations from the Swartland west of Tulbagh in contrast, are white-flowered with brownish orange centres. The filaments in these plants are darkly marked in the middle, and the inner are slightly winged. These populations often co-occur with *O. thyrsoides*, which is common on the coastal side of the mountains, but hybrids between them have not been seen.

Further down the Breede River Valley, between Worcester and Robertson, populations may be either white- or orange-flowered, and the inflorescences, although usually corymbose, may be longer and more conical. In some of these plants all six filaments are winged, the outer filaments with acute, divergent wings and the inner with longer, convergent wings. Both filament whorls are often stained dark in the middle or in the upper parts. A similar degree of variation is evident in the Little Karroo and southern Cape, where populations may be white- or yellow-, or sometimes orange-flowered, and the filaments vary from almost linear to winged.

Yellow-flowered populations are known from south of the Riviersonderend Mountains, between Caledon and Bredasdorp, and formed the basis of *Ornithogalum citrinum*, described by Von Poellnitz from plants collected by Rudolph Schlechter at Genadendal in the southern

foothills of the Riviersonderend Mountains. Plants from higher altitudes throughout the mountains of the southwestern and southern Cape are invariably white-flowered, typically with longer styles, and were previously segregated as *O. fimbrimarginatum* and *O. subcoriaceum*.

Although white-flowered, longer-styled plants typically occur on sandstone soils throughout the mountains of the southwestern Cape, and short-styled plants on inter-montane shale soils east of the Bokkeveld-Hottentots Holland Mountain axis, this ecological-geographical differentiation is not absolute. Yellow- and orange-flowered plants occur, for instance, along the Tsitsikamma Mountains and in the Longkloof on sandstone substrates. Plants from the Witteberg near Laingsburg, including the type of *Ornithogalum fimbrimarginatum*, are long-styled but otherwise match typical *O. dubium* perfectly in their dark centre, blackish green ovary, and filaments with the outer portion flushed olive-green. Apart from the length of the style there is nothing to separate these plants from white-flowered *O. dubium*.

It is now apparent that there are all transitions between short-styled and longer-styled plants, and that style length alone is an insufficient basis for distinguishing between species in the *O. dubium* complex. In the light of the extensive variation in flower colour and filament morphology that is now known to occur within even *O. dubium sensu stricto*, we therefore prefer to recognize a single, variable species in the complex pending more thorough investigation into the population genetics in the group.

The status of *Ornithogalum subcoriaceum* in particular deserves further study. This species was recognized for small plants, rarely up to 200 mm tall, from the interior mountains of the West Coast, typically bearing rather small flowers with tepals 8–14 mm long and bracts that are ciliate towards the apex. In addition, the seeds of collections that we have been able to examine are papillate rather than echinulate as is typical in *O. dubium/O. fimbrimarginatum*. These distinctions, however, are not absolute and larger plants from the Cedarberg that are referable to *O. dubium/O. fimbrimarginatum* on this basis may also have ciliate bracts and papillate seeds. We thus provisionally include the smaller plants within a broadly circumscribed *O. dubium*.

Ornithogalum dubium, unlike *O. thyrsoides*, has been shown to be non-toxic (Obermeyer 1978).

History: *Ornithogalum dubium*, described by Houttyn in 1780, was the second member of section *Aspasia* known to science after *O. thyrsoides*. Other yellow- and orange-flowered plants formed the basis of Jacquin's (1789b) *O. flavescens, O. flavissimum* and *O. miniatum*. All of these were treated as varieties of a very broadly defined *O. thyrsoides* by Baker (1897). The first modern treatment of the species is that of Leighton (1944) but the high degree of variation in flower colour and filament morphology evident in this widespread species led her to distinguish almost a dozen different taxa, based on small differences in the shape and size of the filaments and length of the style. Many of these species were reduced to synonomy under *O. dubium* by Obermeyer (1978), who defined the species more broadly to include all plants with dark bulb tunics, ciliate leaves, and yellow, orange or white flowers with a dark centre and short style. Plants with dark tunics and white flowers with longer styles were excluded from this circumscription and treated as separate species, either *O. subcoriaceum* or *O. fimbrimarginatum*.

Ornithogalum subcoriaceum was described by Louisa Bolus in 1934 from small plants collected on the Bokkeveld Escarpment near Nieuwoudtville that had ciliate bracts near the apex. Although maintaining the species in her treatment of the genus, Obermeyer (1978) recognized its similarity to *O. dubium*, and suggested that the dwarfing might be the result of the colder climate at high altitudes. Plants that match the type of *O. subcoriaceum* occur throughout the mountains of the southwestern Cape inland of the West Coast, from near Nieuwoudtville to Ceres. *Ornithogalum fimbrimarginatum*, described by Leighton in 1944 from plants collected at Whitehill near Matjiesfontein, has never been well understood, and Obermeyer (1978) even considered the possibility that it was a hybrid between *O. dubium* and *O. conicum*, inheriting the dark tunics and expanded inner filaments from the former, and the white flowers and long style from the latter.

Ornithogalum dubium was separated from *O. fimbrimarginatum* and *O. subcoriaceum* by Leighton (1944) and Obermeyer (1978) on the length of the style, which was taken to be less than 2 mm long in *O. dubium* and more than 2 mm long in *O. fimbrimarginatum* and *O. subcoriaceum*. Long-styled plants with dark tunics and white flowers are scattered throughout the mountains of the southwestern and southern Cape, typically growing in moist, shallow soils in sandstone outcrops. Populations with the outer filaments variously broadened were referred by Leighton (1944) severally to *O. leipoldtii*, based on plants from Clanwilliam, *O. pillansii* from Piketberg, and *O. alticolum* from Du Toitskloof, whereas those with the outer filaments linear or lanceolate were determined respectively as *O. fimbrimarginatum* or *O. subcoriaceum*. The distinctly winged inner filaments of the plants referred to *O. leipoldtii* and *O. pillansii* have a dark zone in the middle, thus closely resembling white-flowered forms of *O. dubium*, and both were therefore reduced to synonomy under *O. dubium* by Obermeyer (1978), despite the fact that the length of their styles exceeds the upper limit accepted by her for that species.

There has been some confusion about the identity of *Ornithogalum perpulchrum*, described by Von Poellnitz (1944) from leafless plants collected by Rudolph Schlechter on 10 December 1896 near Elim in the Overberg. Obermeyer (1978) associated these plants with a collection of *O. dubium* made in the vicinity on the same day by Harry Bolus (*Bolus 8696*), who was collecting with Schlechter at the time, but Müller-Doblies & Müller-Doblies (1996) treated *O. perpulchrum* as a synonym of *O. rupestre* (as *O. multifolium*) on the basis that duplicates of both *Schlechter 9681* and *Bolus 8696* that they examined had the leaves of *O. multifolium*. This is, however, most definitely not the case with the Bolus collections in both the Bolus and Kew herbaria, which have the short, oblong, ciliate leaves and dark tunics of *O. dubium*. Similarly, we have no hesitation in identifying

the Kew isotype of Schlechter's collection as *O. dubium*, despite the rather small stature of the plants. There is no doubt that Schlechter's Rietfonteinkloof is correctly located near Elim (Jessop 1964), and *Ornithogalum rupestre* (= *O. multifolium*) is not known from south of the Langeberg, whereas *O. dubium* is common here. All evidence thus confirms that *Ornithogalum perpulchrum* is correctly placed in synonomy under *O. dubium*.

8. **Ornithogalum pruinosum** *F.M.Leight.* in Journal of South African Botany 10: 104 (1944). Type: South Africa, [Northern Cape], between Garies and Kamieskroon, September 1934, *L.Bolus BOL22781* (BOL, holo.!).

O. glaucophyllum Schltr. ex Poelln.: 23 (1944). Type: South Africa, [Northern Cape], Arakup [Arkoep, N of Kamieskroon], 14 September 1897, *R. Schlechter 11249* (Breslau, holo.; BOL!, GRA, K!, PRE, iso.).

Plants (40–)100–400(–650) mm high. *Bulb* sometimes epigeal or nearly so, subglobose, (8–)10–25(–27) mm diam., outer tunics dark brown to black, sometimes reddish apically, firm-textured or leathery. *Leaves* erect, (2)3–6(7), oblong-lanceolate to ovate-lanceolate, (20–)30–200(–300) × (5–)7–25(–35) mm, sometimes crisped, less than half as long as inflorescence, leathery, glaucous, glabrous or margins ciliolate. *Raceme* subcorymbose to cylindrical, (15–)20–50(–70) mm long at flowering, elongating to (30–)50–100(–150) mm in fruit, (4–)8–40(–60)-flowered; lowermost pedicels (5–)6–17(–20) mm long, elongating to (9–)12–25(–30) in fruit; bracts whitish or pale greenish, ovate, acuminate, shorter or longer than pedicels, lowermost (7–)10–30(–45) mm long. *Flowers* glossy white, sometimes with a small greenish or brownish centre; outer tepals ovate-lanceolate, inner tepals obovate, (8)9–15(–20) × (3)4–9(10) mm. *Stamens* half as long as tepals; filaments (3.5–)4.0–7.0(8.0) mm long, white, outer linear, sometimes slightly widened at base, inner either lanceolate or expanded and obovate (sometimes apically lobed) in lower half. *Ovary* ovoid, (2.5–)3.0–5.0(–5.5) mm long, green, yellow or brownish; style erect, (1.5–)2.0–3.0 mm long, yellow. *Capsule* ellipsoid to oblong-ovoid, (5)6–10 mm long, 3-lobed, apiculate. *Seeds* angular-pyriform, 0.5–1.0 mm long, papillate or echinulate. *Chromosomes*: 2n = 12 (Pienaar 1963). *Flowering time*: (July) late August to late September or mid October, rarely into early November. Figures 1H, 14.

Distribution and ecology: widespread through Namaqualand, especially along the western edge of the escarpment between 500–1200 m, from the Richtersveld in the north to Klawer in the south, and extending eastwards to Calvinia on the Bokkeveld Plateau and Aggenys in Bushmanland, with two records from as far east as Kuruman and Augrabies in Gordonia (Figure 15). In the south of its range, in the Knersvlakte, the species occurs along the western foothills of the escarpment below the Bokkeveld plateau, and only extends onto the plateau itself, around Calvinia, from the more arid valleys of southern Bushmanland. Plants typically grow on dry, open stony flats and slopes, and on rocky hillsides, mostly in clay and granite.

Discussion: *Ornithogalum pruinosum* is recognized by its dark, blackish outer bulb tunics, characteristic glaucous, leathery, often undulate leaves that are seldom up to half as long as the inflorescence, and a subcorymbose inflorescence of pure white flowers (rarely with a small dark centre). The yellow ovary and style in many plants is also diagnostic. The small seeds ± 1 mm long, and dark, leathery tunics place the species in the group that includes *O. dubium, O. puberulum, O. maculatum* and *O. rupestre*.

Although centred south of the range of *Ornithogalum pruinosum*, in the southwestern Cape south of Klawer, outlying populations of *O. thyrsoides* have been recorded from the higher-lying parts of central Namaqualand, in the Kamiesberg and near Steinkopf. The two cannot be confused, however, as *O. thyrsoides* is readily distinguished from *O. pruinosum* by the slender, bright green leaves, small bulb with pale tunics, and inner filaments that are conspicuously winged in the lower half and partially obscuring the ovary. In the south, the distribution of *O. pruinosum* also approaches that of *O. strictum* and *O. dubium* but the species do not overlap and confusion between them is unlikely. *O. strictum*, which is common in seasonally damp sites along the Bokkeveld Mountains, has similar flowers but slender, bright green leaves and cylindrical racemes with short pedicels, and *O. dubium*, which has been recorded from similar habitats on the Gifberg, has bright green leaves that are densely ciliate on the margins.

Ornithogalum pruinosum is very variable in stature, ranging in size from small, few-flowered plants scarcely 50 mm high to robust individuals almost 700 mm tall. Plants from Aggenys in the arid eastern Bushmanland are especially dwarfed. This variation is to be expected in a species from arid environments with variable precipitation. Although usually lanceolate, the inner filaments are occasionally expanded at the base, the expansions with small, pointed apical wings. Plants with these winged filaments are scattered through the range of the species, and are known from the Richtersveld, central Namaqualand and Loeriesfontein. The range in form of the inner filaments in the species was evident to Leighton (1944), who noted that they varied in the same population or individual, even in the same flower.

History: *Ornithogalum pruinosum* appears to have been first collected in the late 19th century, first near Kamieskroon by R. Schlechter in the spring of 1897 and a year later at Okiep by W. Morris. Although Schlechter intended describing the species under the name *O. glaucophyllum*, it was only formally recognized in 1944, when it was independently described by both Leighton and Von Poellnitz, the latter using Schlechter's material and his proposed epithet. Since then it has been consistently recognized, and its characteristic glaucous, often undulate leaves have spared it the further taxonomic fragmentation on the basis of the shape of the inner filaments that has been the fate of other species from the southwestern Cape.

9. **Ornithogalum maculatum** *Jacq.*, Collectanea 3: 368 (1791). Type: South Africa, without precise locality or date, Jacq., Collectanea 3: t. 18, f. 3 (icono.!).

O. maculatum Thunb.: 62 (1794), illegitimate homonym. *O. thunbergianum* Baker: 269 (1873), new name for *O. maculatum* Thunb., not of Jacq. (1791). Type: South Africa, [Western Cape], Saldanha Bay, *Thunberg 8289* (UPS, holo.–microfiche!).

FIGURE 14.—*Ornithogalum pruinosum* F.M.Leight.

O. speciosum Baker: 72 (1891), illegitimate homonym. *O. insigne* F.M.Leight.: 113 (1933b), new name for *O. speciosum* Baker, not of Salisb. (1796) or Rafin. (1810). *O. magnificum* Poelln.: 214 (1945), new name for *O. speciosum* Baker. *O. maculatum* Jacq. var. *speciosum* (Baker) F.M.Leight.: 110 (1944). Type: South Africa, [Northern Cape], Namaqualand, without precise locality or date, *W. Scully 175* (K, holo.!, SAM, iso.!).

O. thunbergianum var. *concolor* Baker: 496 (1897). Type: South Africa, without precise locality or date, *Forster s.n.* (K, holo.!).

O. splendens L.Bolus: 14 (1931). *O. maculatum* Jacq. var. *splendens* (L.Bolus) F.M.Leight.: 110 (1944). Type: South Africa, [Northern Cape], near Nieuwoudtville, November 1930, *Buhr 2654/30* (BOL, holo.!).

O. rossouwii U.Müll.-Doblies & D.Müll.-Doblies: 394 (1996), syn. nov. Type: South Africa, [Northern Cape], 2 km N of Buffelsrivier and 32 km N of Laingsburg on Sutherland road, ± 800 m, 4 August 1986 (in leaf), *Müller-Doblies 86037b* (PRE, holo., not located; B, BTU, K, NBG, iso., not located).

Plants (40–)60–400(–550) mm high. *Bulb* subglobose, (7–)8–20(–25) mm diam., outer tunics whitish or grey-brownish, thin-textured. *Leaves* suberect, (1)2–5, linear-lanceolate to oblong-lanceolate, (15–)20–110(–170) × 3–15(–20) mm, obtuse or acute, usually clasping at base, glaucous and entirely glabrous. *Raceme* corymbose to subcorymbose or shortly cylindrical, (5–)10–30(–40) mm long

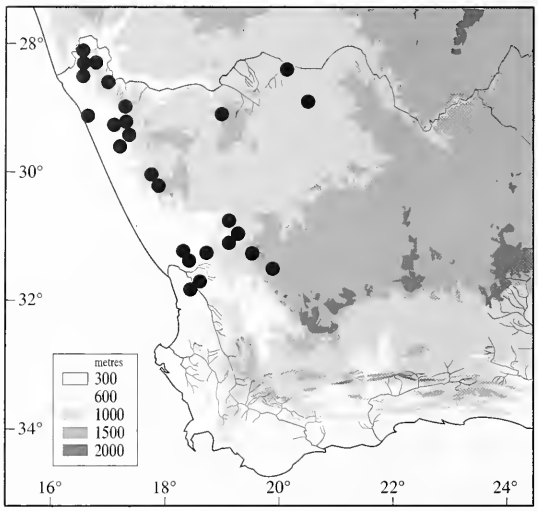

FIGURE 15.—Known distribution of *Ornithogalum pruinosum*.

at flowering, elongating to 25–55(–80) mm long in fruit, 1–6(–9)-flowered; lowermost pedicels 3–15 mm long, elongating to 5–27 mm in fruit; bracts whitish but brownish in outer part, ovate, acute or acuminate, longer than pedicels, lowermost (6–)10–20(–30) mm long. *Perianth* reddish, orange or yellow (rarely white), outer tepals usually with black spot or transverse bar near apex, sometimes unmarked; outer tepals obovate-lanceolate, inner obovate, tepals (10)11–25(–27) × 5–14(–18) mm. *Stamens* ± half as long as tepals; filaments (4–)5–8(–9) mm long, usually orange or yellow, subulate or inner lanceolate. *Ovary* ovoid, 4–8 mm long, yellow; style short and thick, 1.5–2.5 mm long. *Capsule* fusiform to oblong-ovoid, 8–10 mm long, 3-lobed, apiculate. *Seeds* angular-pyriform or comma-shaped, 1 mm long, rugulose. *Chromosomes*: 2n = 12 (24) (Pienaar 1963), 14 (De Wet 1957). *Flowering time*: (late August) September to October. Figures 1I, 16.

Distribution and ecology: localized to the higher-lying parts of central Namaqualand between Springbok and Garies, but widely scattered through the drier parts of the southwestern Cape, from the Bokkeveld Plateau southwards through the Cedarberg and Cold Bokkeveld to Langebaan and Malmesbury on the west coast, thence eastwards along the fringe of the Cape Floral Region to Prince Alfred (Figure 17). Plants are typically restricted to rock outcrops, typically in shallow humus on granite or sandstone pavements, but also outcroppings of shale.

Discussion: *Ornithogalum maculatum* is one of the most striking species in section *Aspasia*, readily recognized by its glaucous leaves lacking any marginal vestiture, orange or yellow flowers, usually with some dark marking at the tips of the outer tepals, and subulate or lanceolate filaments. Forms with pure yellow or orange flowers may be confused with *O. rupestre* but that species has narrow, subterete leaves. The minute seeds and orange flowers might lead to confusion with forms of *O. dubium*, but *O. maculatum* lacks the dark tunics and ciliate leaves that are characteristic of that species.

Ornithogalum maculatum is very variable in stature, flower size and in the development of markings on the flowers. Large forms, with pure orange flowers lacking markings and with broad filaments, originally segregated as *O. splendens,* occur around Calvinia and in Namaqualand between Kamieskroon and Hondeklipbaai. Plants of similar size but with well-marked outer tepals bearing triangular or diamond-shaped markings were distinguished as *O. speciosum* and have been recorded from Namaqualand, between Springbok and Garies, from the Olifants River Valley around Clanwilliam, and from the western Little Karoo, around Karoo Poort, Touws River and Montagu.

The presence and degree of marking may vary within a population, which can thus include both marked and unmarked individuals (e.g. *Van der Merwe 246*). Although typically blackish, the markings on the outer tepals range in colour from green to black, sometimes within a single population (e.g. *Horrocks 12; Hall s.n. NBG68697*). Occasional plants or populations from Karoopoort (*Viviers 1568*), Laingsburg (*Bayliss 736*) and near Steytlerville may lack yellow or orange pigment, producing whitish flowers with darker markings. Such plants formed the basis of *O. rossouwii*.

Anecdotal evidence suggests that the species is not toxic to animals since goats have been recorded as consuming it with impunity (Obermeyer 1978).

History: first described in 1791 by Nicolaas von Jacquin from plants grown in Vienna, *Ornithogalum maculatum* was redescribed a few years later by Thunberg from wild material gathered near Saldanha. Struck by the distinctive marks on the outer tepals, he chose the same epithet for his species. The species is now known to vary not only in flower colour but also in the degree of maculation. Some of the more distinctive of these forms were segregated as distinct species or varieties in the past. Well-marked forms from Namaqualand were segregated as *O. speciosum* by Baker (1891), and an attractive form with large, unmarked yellow or orange flowers from near Nieuwoudtville was named *O. splendens* by Bolus (1931). Both of these forms were later reduced to varietal status by Leighton (1944) but we are in accordance with Obermeyer (1978) in preferring to regard them as local forms within a much greater spectrum of variation and thus not deserving of taxonomic rank. Most recently, Müller-Doblies & Müller-Doblies (1996) described *O. rossouwii* from five greenhouse-grown plants collected between Laingsburg and Janseville, and distinguished from *O. maculatum* by their small size and whitish or pinkish flowers. Although the type material of this species has not been deposited in any herbaria, the accompanying illustrations make its identity clear. The differences between this material and typical *O. maculatum* are trivial when compared to the variation within the species. Several collections of depauperate plants with the yellow, spotted flowers of typical *O. maculatum* (e.g. *Pretorius 92*) are indistinguishable from *O. rossouwii* apart from the colour of the flowers, and these white or cream-coloured plants are most appropriately treated as colour forms of *O. maculatum*. A similar range in flower colour is com-

FIGURE 16.—*Ornithogalum maculatum* Jacq.

mon within *O. dubium* and it is now evident that it also occurs in *O. rupestre.*

10. **Ornithogalum rupestre** *L.f.*, Supplementum plantarum: 199 (1782). Type: South Africa, [Western Cape], Malmesbury Division, Witteklip, *Thunberg 8302* (UPS, holo.–microfiche!).

O. multifolium Baker: 271 (1873), syn nov. Type: South Africa, [Northern Cape], Namaqualand, Modderfontein, *Whitehead s.n.* (TCD, holo.!).

O. virgineum Soland. ex Baker: 271 (1873). Type: South Africa, without precise locality [probably Witteklip], *Masson s.n.* (BM, holo.!).

O. aurantiacum Baker: 748 (1878), syn. nov. Type: South Africa, [Western Cape], Malmesbury District, Groenekloof [Mamre], 1878, *H. Bolus s.n.* (K, holo.!).

O. ranunculoides L.Bolus: 71 (1933b), syn nov. Type: South Africa, [Northern Cape], Steinkopf, *H. Herre STE3978* (BOL!, lecto., here designated).

O. witteklipense F.M.Leight.: 175 (1945). Type: South Africa, [Western Cape], Witteklip near Vredenburg, *Leighton 655* (BOL, holo.!).

O. saxatile Schltr. ms.

Plants (30–)50–150(–200) mm high. *Bulb* subglobose, (7–)10–15 mm diam., outer tunics whitish or brownish. *Leaves* (2)3–10, subterete or canaliculate, 20–110 × 1–3 mm, glabrous. *Raceme* corymbose to subcorymbose, 5–30 mm long at flowering, elongating to 10–50 mm in fruit, (1)2–10(–15)-flowered; lowermost pedicels 2–18 mm long, elongating to 6–25 mm in fruit; bracts ovate, whitish with upper part brownish, acute or acuminate,

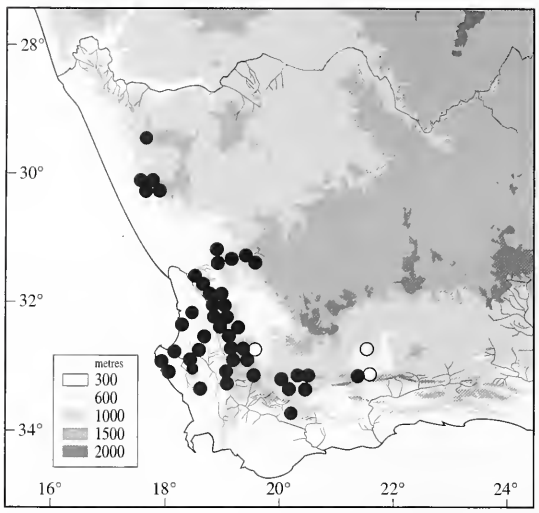

FIGURE 17.—Known distribution of *Ornithogalum maculatum*: white-flowered populations, ○; orange-flowered populations, ●.

usually shorter than pedicels but longer in small plants, lowermost (4–)6–15 mm long. *Flowers* usually yellow or orange, rarely white or pinkish; outer tepals ovate-lanceolate, inner obovate, 6–12 × 3.5–5.5 mm. *Stamens* ± half as long as tepals; filaments 3–5 mm long, whitish or yellowish, outer linear to subulate, inner lanceolate. *Ovary* ovoid, 3–4 mm long, yellowish; style short, erect, 1–2 mm long. *Capsule* fusiform to oblong-ovoid, 10 mm long, 3-lobed, apiculate. *Seeds* angular-pyriform or comma-shaped, 0.75 mm long, rugulose. *Chromosomes*: 2n = 12 (Pienaar 1963), 20 (Johnson & Brandham 1996). *Flowering time*: late August to early October. Figures 1J, 18.

Distribution and ecology: widely distributed through Namaqualand and the more arid southwestern Cape, from the Richtersveld in the north through the higher-lying parts of Namaqualand to the Bokkeveld Plateau, southwards through the northern Cedarberg to Darling in the southwest, and through the Cold Bokkeveld to Barrydale and Laingsburg in the southeast, with isolated records from the Roggeveld Escarpment (Figure 19). Plants grow in shallow humus and soil on rock sheets, often on granite or sandstone, where they may occur in large numbers fringing depressions on the rocks that accumulate water in the rainy season.

Discussion: *Ornithogalum rupestre* is one of the most recognizable species in the section, identified by the few to many, subterete, glabrous leaves. Other species in section *Aspasia* have plane, oblong to lanceolate leaves. It is typically less than 100 mm high, with pure yellow or orange flowers with linear to lanceolate filaments and a very short style. *O. rupestre* shares glabrous leaves, mostly yellow or orange flowers with a rudimentary style, and minute, rugulose seeds with *O. maculatum* and it is likely that the two are immediately related. The flowers of *O. rupestre* are typically bright yellow or orange but populations from Langebaan and the Cold Bokkeveld have pale yellow flowers, and plants with cream-coloured flowers have been collected around Pakhuis Pass. The flowers of populations from the Vredenburg Peninsula are uniformly white or pinkish.

History: *Ornithogalum rupestre* was described by Linneaus f. (1782) from plants collected on Witteklip near Vredenburg by Carl Peter Thunberg. Although not mentioned in the original description, the plants from Witteklip are uniformly white-flowered, sometimes with a pinkish flush. Later collections of the more common and widespread yellow-flowered forms were described as *O. multifolium,* based on short, floriferous plants from Namaqualand (Baker 1873), and *O. aurantiacum,* from few-flowered plants collected near Mamre (Baker 1897). Yet another name, *O. ranunculoides,* was applied to taller forms from Namaqualand by Louisa Bolus (1933b). All of these forms were subsequently included within a single yellow-flowered taxon, *O. multifolium*, by both Obermeyer (1978) and Müller-Doblies & Müller-Doblies (1996). White-flowered *O. rupestre* from Vredenburg has until now been retained as distinct from yellow-flowered *O. multifolium*. The application of the name *O. rupestre* was confused by Leighton (1944), who used it for yellow-flowered plants (Obermeyer 1978), but there is no doubt that the type is white-flowered.

White-flowered *Ornithogalum rupestre* was separated from yellow-flowered *O. multifolium* on nothing more than flower colour, a minute difference in style length, and the smaller stature of the former. It is now clear that flower colour varies within the species in the group and is an insufficient basis for separating species. Even within yellow-flowered plants, flower colour may range from pale lemon-yellow through bright canary yellow to orange, whereas paler forms may be white, cream-coloured or pinkish. The purported differences in stature and style length are likewise trivial and we have no hesitation in including the various colour forms within a single species. It is unfortunate that *O. rupestre* is the earlier name for this taxon, which is better known under the name *O. multifolium*.

11. **Ornithogalum leeupoortense** *U.Müll.-Doblies & D.Müll.-Doblies* in Feddes Repertorium 107: 396 (1996). Type: South Africa, Northern Cape, Bushmanland, Naip Mountains, (–AD), June 1988, *E.J. van Jaarsveld 9478* (NBG!, neotype, here designated).

Plants 60–150 mm high. *Bulb* subglobose, 10–15 mm diam., outer tunics dark brown to black, somewhat leathery. *Leaves* falcate, distichous, (2–)5 or 6, lanceolate-attenuate, canaliculate, ± as long as inflorescence or longer, (25–)40–15 × (4–)5–10 mm, leathery, bright green, margins translucent and papillate, sometimes thickened. *Raceme* often laterally displaced by development of second inflorescence, corymbose, 20–50 mm long at flowering, (1–)4–15-flowered; lowermost pedicels (15–)20–30 mm long; bracts pale greenish, lanceolate-attenuate, shorter or longer than pedicels, lowermost (15–)20–25 mm long. *Flowers* glossy white; outer tepals elliptic-ovate, inner tepals elliptic-obovate, 13–20 × 5–8 mm. *Stamens* less than half as long as tepals; filaments 5.0–6.5 mm long, white, outer linear or subulate, inner linear-lanceolate. *Ovary* ovoid, 4–6 mm long, green; style erect, 2–3 mm long. *Capsule* ellipsoid to oblong-ovoid, 6–7 mm long, 3-lobed, apiculate. *Seeds* angular-pyriform, 0.5–1.0 mm long, echinulate. *Flowering time*: August to September. Figures 1K, 20.

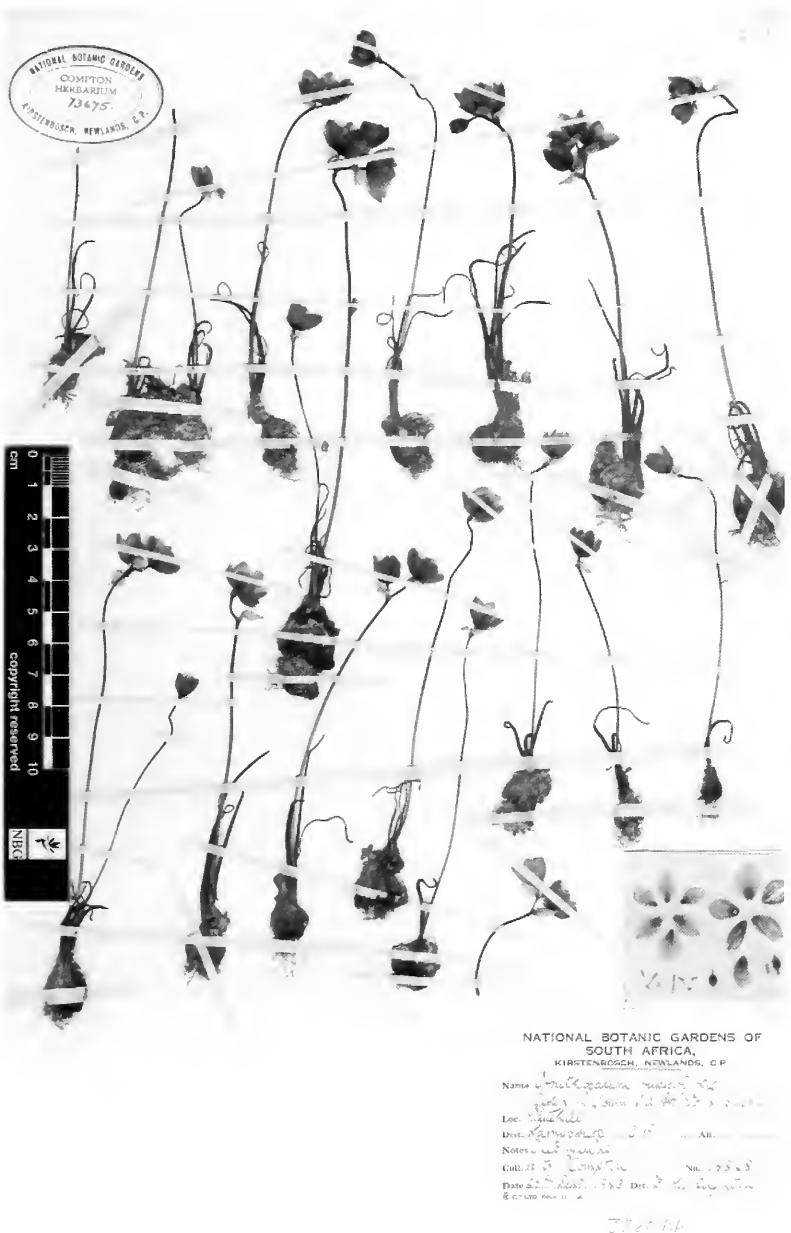

FIGURE 18.—*Ornithogalum rupestre* L.f.

Distribution and ecology: currently known from the hills northeast of Springbok, with most of the collections from the inselberg Naip se Berg, and from further north on the higher mountains of the Richtersveld, between 800–1 000 m (Figure 21). Plants grow wedged in crevices and fissures in quartzite rock and scree on sheltered, south-facing slopes, where they may be locally abundant.

Discussion: still poorly collected and understood, *Ornithogalum leeupoortense* is distinguished by the fan-like arrangement of its leaves, which are falcate, pointed and somewhat channelled. The leaf margins are obscurely papillate and in the populations around Springbok they are also distinctly thickened. Plants typically produce a second inflorescence in a growing season and the older inflorescence is characteristically displaced, appearing to arise in the axil of one of the lower leaves. The relatively short inflorescence is characterized by large, often foliose, green bracts, the lowermost 15–25 mm long, with the tips drawn out and attenuate.

Collections from the Richtersveld, although lacking the thickened leaf margins of plants from around Springbok, match the southern populations in all other

essentials, including the falcate, glossy green leaves with attenuate tips, and lateral displacement of the primary inflorescence through development of a later one, and we have no hesitation in regarding them as conspecific.

The minute, echinulate seeds of *Ornithogalum leeupoortense* indicate an alliance with the members of the *O. dubium* group but it is unlikely to be confused with any other species in series *Maculata* on account of the distinctive glossy green, distichous leaves. Most other species of the group from Namaqualand, particularly *O. pruinosum* and *O. maculatum*, have rosulate, glaucous leaves. Pressed specimens of *O. pruinosum* may be distinguished by their erect, proportionally broader leaves with ciliolate, often crisped margins. The leaves are also typically shorter, less than half as long as the inflorescence, and thick-textured.

History: the species was described by Müller-Doblies & Müller-Doblies (1996) from a collection of non-flowering plants made on 11 August 1988 on the Farm Leeupoort northeast of Springbok and subsequently grown on in the glasshouse. None of the cited material has been deposited in any herbarium but three collections of plants, all from Naip se Berg on the edge of Bushmanland northeast of Springbok, match the protologue in the diagnostic essentials, viz. the distichous leaves with thickened, obscurely papillate margins, and are accordingly referred to this species. Since no type material has been lodged in the cited herbaria, we select one of these specimens to act as a neotype. The earliest collection of the species that we have traced is that made by Margaret Thompson and Annelise le Roux in August 1977 in the Richtersveld and until now referred either to *O. subcoriaecum* (now a synonym of *O. dubium*) or *O. pruinosum*.

12. **Ornithogalum puberulum** *Oberm.* in Bothalia 12: 337 (1978). Type: Namibia, Kahanstal, 5 miles [8 km] N of Loreley [Lorelei], 30 August 1963, *H. Mueller & W. Giess 3365* (PRE, holo.!).

O. merxmuelleri Roessler: 389 (1979). Type: Namibia, Farm Namuskluft, 29 September 1977, *Merxmüller & Giess 32350* (M, holo.; PRE!, WIND, iso.).

O. puberulum subsp. *chris-bayeri* U.Müll.-Doblies & D.Müll.-Doblies: 390 (1996), syn. nov. Type: Namibia, mountain 2 km west of Rosh Pinah, ± 450 m, 26 September 1989, *Müller-Doblies 89120b* (WIND, holo., not deposited).

Plants 50–80(–90) mm tall. *Bulb* subglobose, 8–15 mm diam., outer tunics leathery or somewhat cartilaginous, whitish or dark grey, sometimes forming a short neck of narrow fragments. *Leaves* suberect or spreading, 2(3), synanthous, oblong to ovate-lanceolate, rarely lanceolate, uppermost usually only half as large as lower, 40–80 × 10–25 mm, soft-textured, glabrous or pubescent on both surfaces, margins with slender cilia 0.75–2.0 mm long, base shortly tubular, somewhat inflated and clasping scape. *Raceme* corymbose or racemose, 15–100(–130) mm long at flowering, 4–10(–25)-flowered; lowermost pedicels 10–20 mm long in flower, elongating to 30 mm; bracts whitish, ovate, acute or acuminate, glabrous or lowermost ciliate, shorter or longer than pedicels, lowermost 8–16 mm long. *Flowers* white; outer tepals

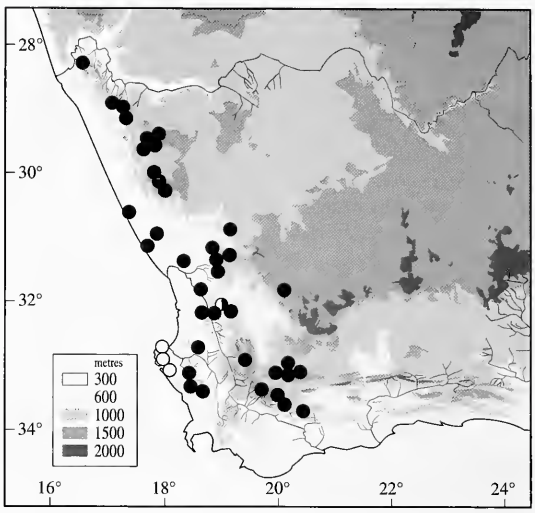

FIGURE 19.—Known distribution of *Ornithogalum rupestre*: white- or pale yellow-flowered populations, ○; deep yellow- or orange-flowered populations, ●.

ovate-lanceolate, inner eliptical-ovate, 6–10 × 3–5 mm. *Stamens* ± half as long as tepals; filaments lanceolate, 4–5 mm long, white, sometimes marked with yellow, inner with quadrate or apically auriculate expansion in lower 2 mm. *Ovary* ovoid, ± 4 mm long, sometimes greenish black apically; style 1.5–3.0 mm long. *Capsule* ovoid, 6–8 mm long. *Seeds* angular, ± 1 mm long, colliculate to echinulate. *Flowering time*: August and September. Figures 1L, 21.

Distribution and ecology: largely restricted to a small area of high ground in southern Namibia, between 600–950 m, in the Klinghardt Mountains and nearby Huib Hoch Plateau (Figure 22), with a southward extension into the Richtersveld in Northern Cape, South Africa around Lekkersing. This is an extremely arid region that is summer-dry, although coastal fogs supply some precipitation in the autumn.

The leaves of *Ornithogalum puberulum* are remarkably soft-textured for a species from such an arid area and plants are restricted to rock outcrops and crevices, on south-facing exposures or at the foot of boulders, where they are sheltered from the afternoon sun in winter and benefit from the cooler, moist conditions during the growing season. The species has been recorded as locally common where it occurs but leafing and flowering is dependent on adequate rain.

Discussion: this highly distinctive species is immediately recognizable by the two (rarely three) soft-textured, ovate to elliptical (rarely lanceolate) leaves that are either glabrous or pubescent but always with soft cilia 0.7–2.0 mm long on the margins. The leaves of *Ornithogalum puberulum* are typically rather tubular and inflated at the base where they clasp the stem, and the upper leaf is mostly only half the size of the lower one or two.

The species shows considerable variation in the pubescence of the leaves, sometimes within populations

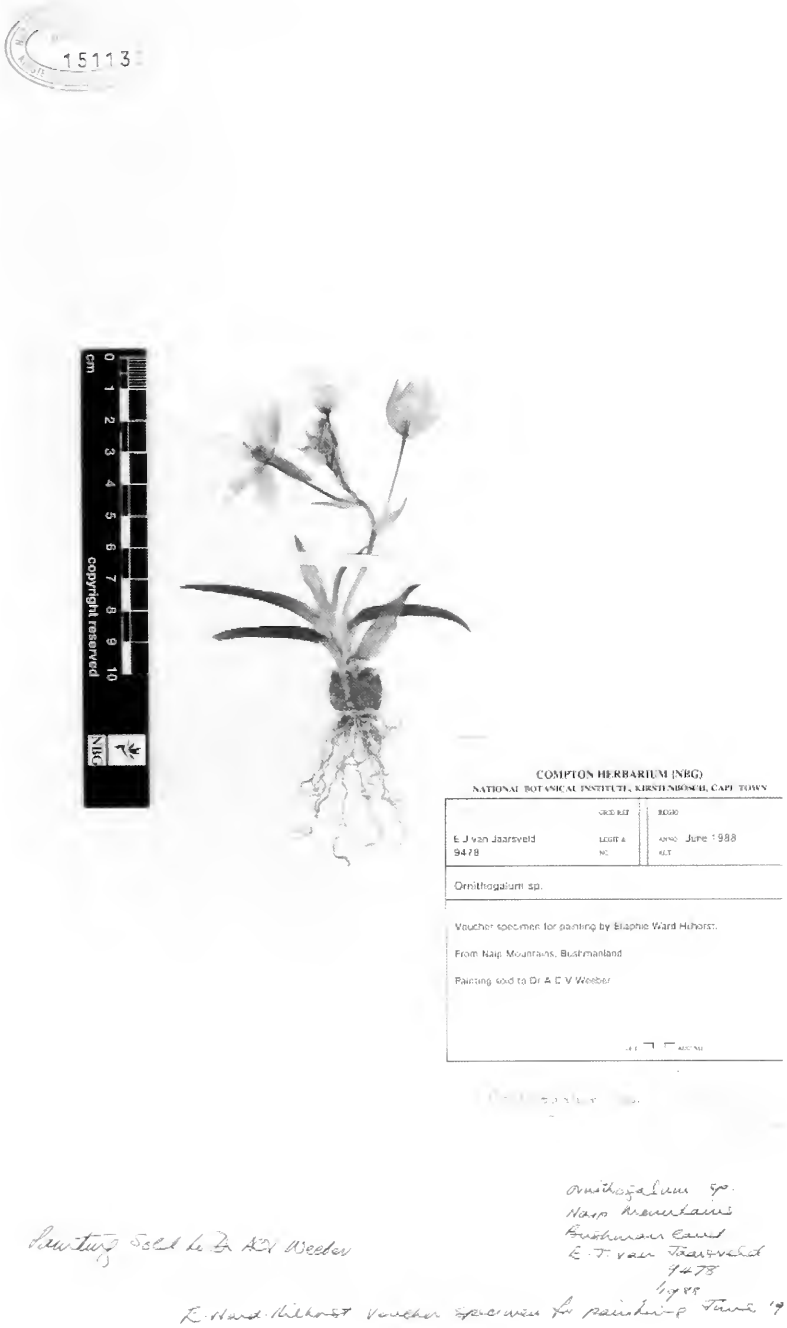

FIGURE 20.—*Ornithogalum leeupoortense* U.Müll.-Doblies & D.Müll.-Doblies.

but more usually between them. The type collection comprises four plants, all of which have leaves that are entirely pubescent on both surfaces, apart from the upper leaf on one of the plants, which is pubescent only apically. The leaf and bract margins in all four plants are densely ciliate. The type of *Ornithogalum merxmuelleri* has similarly pubescent leaves but the bracts are entirely glabrous. All other collections that we have examined have leaves that are glabrous with sparsely pubescent margins. Although both the type and *Bruyns 2668* have ciliate margins to the bracts, other populations from near Rosh Pinah (*Bruyns 8359, 8866*) have entirely glabrous bracts.

Described from near Rosh Pinah in southern Namibia, *Ornithogalum puberulum* subsp. *chris-bayeri* Müll.-Doblies & Müll.-Doblies was distinguished from the typical subspecies by the shorter cilia on the leaf margins, hairy bracts, yellow-spotted filaments and shorter style (1.6 mm vs 2.5–3.0 mm). More recent collections of *O. puberulum*, with somewhat variably ciliate leaf margins, glabrous or ciliate bracts and short styles, that

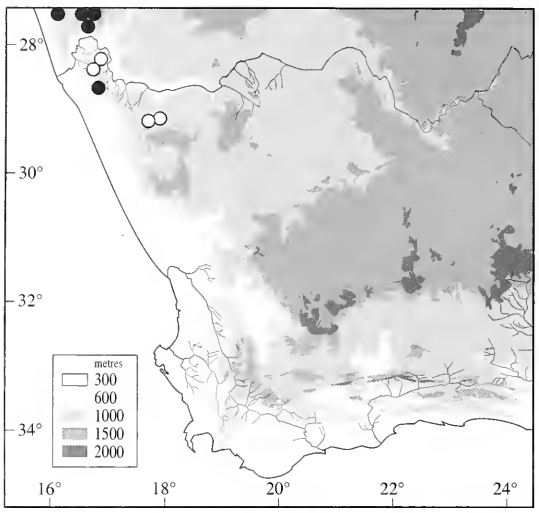

FIGURE 21.—Known distribution of *Ornithogalum leeupoortense*, ○; *O. puberulum*, ●.

have subsequently been made near Rosh Pinah (*Bruyns 2778, 8359, 8866*) indicate that the species is more variable than was previously supposed and that the recognition of this subspecies is unwarranted.

Typical *Ornithogalum puberulum* from southern Namibia is characterized by a rather corymbose inflorescence with up to 15 flowers. Populations of vegetatively similar plants from near Lekkersing in the Richtersveld (*Oliver, Tölken & Venter 776*; *Thompson & Le Roux 85*), however, have elongate, cylindrical inflorescences with up to 25 flowers, giving them a very different appearance. These plants were associated with *O. puberulum* without comment by Müller-Doblies & Müller-Doblies (1996). Although a similar range in inflorescence form is shown by other species in the group, including *O. prunosum*, the status of these populations requires further investigation.

The characteristic leaves of *Ornithogalum puberulum*, clasping at the base and with long-ciliate margins, have led to confusion with *O. hispidum* in the herbarium. The latter species, a member of section *Hispidaspasia*, is readily distinguished by its small bracts, and narrow raceme of smaller flowers with filiform filaments.

History: *Ornithogalum puberulum* was described by Obermeyer (1978) from plants collected fifteen years earlier in southern Namibia. *Ornithogalum merxmuellerí*, described the following year by Roessler (1979) from fruiting material collected in the same area of southern Namibia, does not appear to differ in any significant way and was synonymized under *O. puberulum* by Müller-Doblies & Müller-Doblies (1996).

At the same time, Müller-Doblies & Müller-Doblies (1996) described *O. puberulum* subsp. *chris-bayeri* from plants that they had collected near Rosh Pinah in southern Namibia, distinguishing it by the shorter cilia on the leaf margins, hairy bracts, and yellow-spotted filaments and short style. These differences are, however, not significant in the light of more recent collections. We owe much of our knowledge of the species to the recent collections made by the Cape Town succulent specialist, P.V. Bruyns.

Excluded species

1. *Ornithogalum baurii* Baker in Flora capensis 6: 504 (1897). Type: South Africa, Eastern Cape [Transkei], Baziya Mountain, 4000' [1 220 m], November without year, *Baur 552* (K, holo.!; SAM, iso.!).

O. hygrophilum Hilliard & B.L.Burtt: 195 (1988). Type: Eastern Cape [Transkei], NW of Umtata, hill above Mhlahlane Forest Station, 10 December 1985, *Hilliard & Burtt 19768* (E, holo.; K!, NU, PRE, iso.).

2. *Ornithogalum diphyllum* Baker in Kew Bulletin 1895: 153 (1895). Type: South Africa, [KwaZulu-Natal], Ntabamhlope Mountain, *Evans 374* (K, holo.!; PRE–photo.!).

3. *Ornithogalum sephtonii* Hilliard & B.L.Burtt in Notes from the Royal Botanic Garden Edinburgh 41: 308 (1983). Type: South Africa, Eastern Cape, Barkly East Dist., Ben Mcdhui, ± 8100' [± 2 466 m], 3 December 1981, *Hilliard & Burtt 14665* (E, holo.; NU, iso.).

These three taxa comprise a group of poorly understood species known from isolated localities along the mountains of the Eastern Cape and KwaZulu-Natal. They are all small or dwarf plants with two or three leaves and subcorymbose racemes of pure white flowers subtended by foliar bracts. The seeds of *Ornithogalum diphyllum* are club-shaped and echinulate (Obermeyer 1978) and those of *O. sephtonii* tetragonal and reticulate (Hilliard & Burtt 1983). In the light of this, Obermeyer (1978) and Müller-Doblies & Müller-Doblies (1996) had little hesitation in associating this group of species with section *Aspasia* from the Western and Eastern Cape, despite the obvious anomaly in their distribution. They were interpreted by Obermeyer (1978) and others as isolated montane relics of the Cape section *Aspasia*.

At the same time Obermeyer (1978) included *O. baurii* and *O. synanthifolium*, both of which had been collected by Baur at Baziya in Eastern Cape, in a broadly circumscribed *O. conicum*. There is little doubt, however, that *O. baurii* and *O. synanthifolium* are distinct species (see Discussion under the latter), an opinion that was first aired by Hilliard & Burtt (1988, 1989). What is not as evident, however, is where the affinities of *O. baurii, O. diphyllum* and *O. sephtonii* lie. While there is certainly a superficial similarity in vegetative and floral morphology between these three species and those of section *Aspasia*, particularly in their foliar bracts and moderate-sized, white flowers, and while the seeds of *O. diphyllum* at least have some resemblance to those of other species in the section, the capsules of this group are not at all like those that characterize section *Aspasia*. All three species have distinctly turbinate, 3-angled capsules that are exposed by the reflexing of the tepals. Such capsules are anomalous in section *Aspasia*, which is characterized by ellipsoid or ovoid, obscurely angled capsules that are concealed by the persistent, papery perianth. On this basis alone the three species of the *O. baurii* group should be excluded from section *Aspasia*.

FIGURE 22.—*Ornithogalum puberulum* Oberm.

Support for this interpretation is provided by DNA sequence data (Manning *et al.* in prep.), which places *O. sephtonii* among the residue of species previously grouped within subgenus *Urophyllon*, where such turbinate capsules are common, and not among the species of subgenus *Aspasia*. We accordingly exclude these three species from section *Aspasia*. The differences between them are relatively minor and further study is likely to reduce the number of taxa.

ACKNOWLEDGEMENTS

Our thanks to Elizabeth Parker and Dave Gwynne-Evans for assistance in the field and to Michelle Smith for scanning the specimens used in the illustrations. We are also grateful to the curators of the various herbaria for access to their collections. Clare Archer is thanked for her assistance with specific queries. Additional material was collected under permits from the Northern and the Western Cape Nature Conservation authorities.

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OTHER SPECIMENS EXAMINED

Acocks 14767 (8) K. *Andreae 177, 764* NBG. *Axelson 105, 359* (5) NBG.

Barker 9738 (1) NBG; *1916* (2) NBG; *295, 4766, 9478, 9796, 10330* (4) NBG; *1919* (5) BOL, NBG; *1917,1923, 1935, 2570, 2606, 2646, 3332, 4198, 4858, 10534, 10801* (5) NBG; *BOL22845* (6) BOL; *87* (7) BOL, K; *BOL27865* (7) BOL; *292, 1576, 1922, 2406, 2581, 4259, 4266, 4898, 5347, 6035, 6814, 6859, 6879, 6994, 7292, 7579, 7605, 9106, 9135, 9585* (7) NBG; *1928, 5705, 7323, 7324, 7415, 9486, 9503* (8) NBG; *294, 1921, 1925, 2656, 2662, 3069, 4758, 6574, 7446, 9194, 10752* (9) NBG; *1079, 1932, 1933, 6761, 9024, 10310, 10763* (10) NBG. *Batten 2.100.82* (2) NBG; *91* (7) NBG. *Baur 508* (2) K, SAM. *Bayer 3629* (7) NBG. *Bayliss 6164* (7) NBG; *736* (9) NBG; *275, 276* (10) NBG. *Bohnen 4733, 7052, 7536, 7537, 7966, 8732* (7) NBG. *Bolus 4350* (5) BOL; *NBG73561* (5) BOL, NBG; *8696, BOL410/33* (7) BOL; *1256/32* (7) NBG; *20349* (7) BOL, K; *6597* (8) BOL; *4346* (9) K; *BOL12892, BOL13065* (10) BOL. *Bond 183* (3) BOL, NBG; *BOL22801* (3) BOL; *522* (5) NBG; *733* (7) NBG; *548* (9) NBG. *Botha (3)109* (7) NBG. *Boucher 2617* (5) K, NBG; *4117, 6361, 6476, 6477* (5) NBG; *2699, 3024* (7) NBG; *3136* (8) NBG; *2838, 6562* (9) NBG; *3338, 4717, 5687* (10) NBG. *Browne NBG123/37* (7) NBG. *Brownlee BOL 22175, BOL22714* (7) BOL. *Bruyns 1848* (7) NBG; *9218* (10) NBG; *2771, 2778, 8359, 8866* (12) NBG. *Buhr STE119639* (9) NBG. *Burchell 6198* (7) K. *Burgers 1279, 1390* (7) NBG. *Buys 481* (7) NBG.

Cassidy 127 (1) BOL, NBG. *Compton 12546, 16589* (1) NBG; *17769* (2) NBG; *3171/34, 9514, 11781, 12335, 15259, 15260, 15261, 15263, 16374, 18815* (5) NBG; *12082* (6) BOL, NBG; *3587, 9623, 9738, 9967, 11680, 12151, 12457, 12772, 139/45, 15238, 16388, 16491, 16742, 16885, 17861, 18718, 18982, 21151, 21681, 21732, 22232, 23179, NBG24/34, NBG261/44* (7) NBG; *5251, BOL55470, NBG139/45* (7) BOL; *12058* (7) BOL, NBG; *22072* (8) NBG; *3565, 9571, 9692, 11700, 14846, 16138, 20839, 20876, 24200, 24302* (9) NBG; *BOL1528* (10) BOL; *3585, 14848* (10) BOL, NBG; *9288, 9611, 11773, 11891, 16301* (10) NBG. *Compton et al. 2011/36* (4) NBG. *Cook BOL1766/25* (7) BOL. *Cowling 1906, 1907A* (7) NBG. *Craven 179* (5) NBG. *Cross 71, 72* (5) NBG. *Cruz 98* (9) NBG.

Davison 32 (7) SAM. *De Villiers 949/62* (7) NBG. *De Vos 154* (5) NBG. *Desmet 361* (8) NBG; *1941* (10) NBG; *3063* (11) NBG. *Dobay 81* (7) NBG. *Drège 1512, 2662* (10) K. *Du Plessis 58, 59* (7) NBG.

Ebersohn 370 (5) NBG. *Ecklon 569* (1) K. *Edwards 93/29* (7) NBG. *Emdon 174, 253* (7) NBG. *Esterhuysen 11497* (1) BOL; *1433* (5) BOL; *71402* (5) NBG; *1771, 4390, 7278, 9317, 9392, 11207, 11280, 18327, BOL7/42* (7) BOL; *2941, NBG73514, NBG73568* (7) NBG; *3781, 14957* (7) BOL, NBG; *4384, 22100* (10) BOL.

Fellingham 474 (5) NBG; *1089/5* (7) NBG; *176* (9) NBG. *Flanagan 788* (2) BOL; *2238* (7) BOL, K. *Forrester 102, 931* (7) NBG. *Fourcade 512 4175* (7) BOL, K, NBG; *5159A, 5866* (7) BOL.

Galpin 312 (2) K; *311* (7) K. *Germishuizen 4063, 4156* (7) NBG. *Gillett 1914, 4289* (7) BOL; *3384* (7) NBG; *380* (9) NBG. *Glass 380* (2) NBG; *379, 381* (7) NBG. *Goatcher BOL13726* (6) BOL, K. *Goldblatt, Manning & Savolainen 11526* (8) NBG. *Goulimis BOL22775* (1) BOL; *BOL22809* (7) BOL. *Grobler 491* (7) NBG. *Guthrie 2390, 2768* (7) NBG.

Hall 4542 (1) NBG; *NBG88092* (3) NBG; *3110* (4) K, NBG; *272, 1504, 4511, NBG73519* (7) NBG; *325, 833, 4929* (8) NBG; *958, NBG68697* (9) NBG; *475/52, 4930, 5195, 5217, NBG73664* (10) NBG; *5062* (10) K, NBG. *Hanekom 2616* (5) K, NBG; *3108* (5) NBG. *Harrower 3001* (7) NBG. *Heathie BOL3710* (6) BOL. *Heese*

STE10173 (7) NBG. *Heginbotham 164* (7) NBG; *43* (9) NBG. *Herre BOL3966* (4) BOL; *STE1235-4, STE17465* (8) NBG; *STE17458, STE19638* (10) NBG). *Hiemstra 470* (8) NBG. *Hilton-Taylor 1990, 2036* (7) NBG; *1991* (9) NBG. *Horrocks 12, 29* (9) NBG. *Hugo 2061* (7) K, NBG; *2915* (8) NBG. *Hurling NBG73531* (7) NBG. *Hutchinson 1116* (7) BOL, K; *767* (10) BOL, K.

IBSA NBG207216 (3) NBG. *Isaac 7234* (10) BOL.

James 134044, 233844, BOL 3277/32 (7) BOL. *Jones STE30397* (7) NBG. *Jordan STE25508* (5) NBG. *Joubert (e)* (7) NBG; *(c.)* (9) NBG.

Kellerman 11 (9) NBG. *Kemper IPC740* (7) NBG. *Kensit BOL22843* (7) BOL. *Kerfoot 5907* (9) NBG. *Kolbe BOL14312* (8) BOL. *Kruger 44* (5) NBG. *Kurzweil 1271* (5) NBG.

Lamb BOL1644/30 (4) BOL; *BOL1619/30* (7) BOL. *Laughton NBG22685* (7) NBG. *Lavis BOL22152* (5) BOL; *BOL22831* (7) BOL. *Le Roux 2837* (5) NBG; *2505* (8) NBG; *2781A* (8) BOL. *Le Roux & Ramsey 326* (10) NBG. *Lechmere-Oertel 355* (9) NBG. *Leighton 175* (1) BOL; *1495/33* (4) NBG; *BOL1492/33* (4) BOL; *135, 137* (5) K, NBG; *138, 163, 164, 170, 189, 195, 196* (5) NBG; *188* (5) BOL, NBG; *BOL22700, BOL22701* (5) BOL; *134, 136, 1503/33* (7) NBG; *694, 717, 2200* (7) BOL; *275/45* (8) NBG; *3155* (8) BOL; *161, 655, 3159* (10) BOL; *1051* (10) BOL, NBG. *Leipoldt 4374* (4) BOL; *4028* (8) BOL, NBG; *BOL1048/36* (8) BOL; *NBG73654* (8) NBG; *782* (9) NBG; *3357, 4090, 4379* (10) BOL). *Levyns BOL1292* (4) BOL; *3470, 4795, BOL5763a, BOL7233* (7) BOL; *1776, BOL4631, BOL7232* (9) BOL; *11652, BOL7235* (10) BOL. *Lewis 2185* (1) SAM; *BOL22799* (4) BOL; *5070* (5) NBG; *5701* (7) NBG; *BOL22088, BOL22853, NBG2696/32* (7) BOL; *279* (8) NBG; *1425, SAM55743, SAM62315, SAM62316* (8) SAM; *5899* (9) NBG; *BOL22856, BOL22858* (10) BOL). *Lombard s.n.* (8) NBG. *Louw 2689* (5) NBG. *Low 8630* (9) NBG.

MacKinnon s.n. (7) NBG. *MacOwan 2652* (1) K, SAM; *20* (2) BOL; *940* (5) BOL, K; *505, 1819* (7) BOL, K. *Maguire 2004* (8) NBG; *238* (9) NBG. *Malherbe STE30398* (7) NBG. *Manning 2655* (4) NBG; *2654* (5) NBG; *2650* (7) NBG; *1036* (9) NBG. *Manning & Martínez-Azorín 3* (4) NBG; *13, 63, 64, 83* (5) NBG; *1, 12* (6) NBG; *4, 5, 6, 8, 10, 60, 61, 62, 82* (7) NBG. *Manning & Snijman 2722* (7) NBG. *Marais 1* (1) NBG; *BOL71519* (2) BOL. *Marloth 11486* (5) NBG; *9572, 10781* (7) NBG; *12350, 12855* (8) NBG; *11497* (9) NBG; *11496* (10) NBG. *Marsh 1043* (5) NBG; *462* (8) NBG; *479* (9) NBG; *BOL1667/30* (9) BOL. *Martin 836* (8) NBG; *69* (9) NBG. *Martínez-Azorín 95* (4) NBG. *Martley BOL22776, BOL22777* (1) BOL. *Mathews BOL22704* (7) BOL; *BOL27883* (9) BOL. *Mauve & Hugo 19, 51* (5) NBG. *Mauve, Reid & Wikner 91* (7) NBG. *McDonald 1641* (7) NBG. *Meyer STE9067* (9) NBG. *Middlemost NBG73521* (7) NBG. *Mitchell 1154* (10) NBG. *Moffett 375, 451* (7) NBG. *Montgomery 232* (5) NBG; *75,* (7) NBG. *Morley 230* (5) NBG; *325* (7) NBG. *Morris BOL5805* (8) BOL, K. *Mucina 080905/14* (11) NBG. *Muir 1164, 4989* (7) NBG.

NBG Expedition 175/65 (4) NBG. *Nieuwoudt s.n.* (9) BOL, K. *Nordenstam 2853* (10) NBG.

O'Callagham 1303 (5) NBG. *Oliver 3691, 5133* (5) NBG; *5179* (7) K, NBG; *4801, 5028, 5160, 5188, 5298, 5475, 5501, 9759* (7) NBG; *3868, 4024, 9567, 9711* (9) NBG; *10191* (12) NBG. *Oliver, Tölken & Venter NBG169104* (8) NBG; *776* (12) NBG. *Olivier 834, 874* (7) NBG. *Orchard 323* (7) K, NBG.

Palmer 244 (7) NBG. *Pappe SAM23321* (1) SAM. *Paterson-Jones 663, 704* (5) NBG; *683, 719* (7) NBG. *Peers BOL27889* (1) BOL; *BOL27929* (5) BOL. *Pegler 219* (2) BOL, K, SAM. *Pells BOL22706* (7) BOL. *Perry 3366* (3) NBG. *Perry & Snijman 2423* (4) NBG. *Phillips 1080* (7) BOL; *2084* (7) SAM; *7624* (7) NBG; *7543* (9) NBG. *Pienaar 8* (2) NBG. *Pillans 8370* (1) BOL; *8959, 9851* (5) BOL; *10890* (5) NBG; *8115* (7) BOL; *9566* (7) BOL, K, NBG; *4935, 5448* (8) BOL. *Plowes NBG120374* (9) NBG. *Pocock 467, 647* (7) NBG; *162* (9) NBG. *Pond 117* (9) NBG. *Pretorius 626* (4) NBG; *547* (7) NBG; *92* (9) NBG; *374* (10) NBG.

Rode & Boucher 0180 (5) NBG. *Rogers 27540* (7) BOL, K; *28224* (6) BOL, K, SAM; *BOL12941* (7) BOL; *STE12770* (7) NBG. *Rösch 273* (3) NBG; *664* (4) NBG. *Ross-Frames 1241/26* (5) NBG; *BOL1259/26* (8) BOL. *Rouoc STE18987* (5) NBG. *Rourke 617, 650* (7) NBG. *Rycroft 2372, 2760, 3020* (7) NBG. *Ryder 2272/30* (4) NBG; *3169/34* (7) NBG.

Salter BOL869/32 (1) BOL; *2755, 2805* (4) BOL, K; *590/32, 1213/33* (5) NBG; *4978* (5) BOL; *BOL7816* (5) BOL, NBG; *2718* (7) BOL; *2779* (7) BOL, K; *2746,* (10) BOL, K; *6226* (10) BOL. *Schlechter 9131* (7) BOL; *STE9011, STE10883* (8) NBG; *1421* (9) K; *STE10882* (9) NBG; *11368, 11487* (10) BOL, K. *Schonken 307* (7) NBG. *Scott BOL2212/31* (7) BOL. *Smith 6447* (4) NBG; *137, 2658* (5) NBG; *2659, 2869, 2870* (7) NBG; *6446* (8) NBG. *Smuts s.n.* (7) NBG. *Snijman 376, 1370* (7) NBG; *1125* (9) NBG; *269, 1922* (10) NBG. *Solomon 106* (5) NBG. *Starket BOL17831* (9) BOL. *Stayner NBG73547* (7) NBG. *Steiner 2914, 3024* (7) NBG; *2917* (7) K, NBG. *Stephens & Glover 8632* (9) K, NBG. *Steyn 488* (9) NBG. *Stobie 24, 38* (10) NBG. *Stokoe 7605* (7) BOL; *SAM63139, SAM64702* (7) SAM; *SAM60648* (8) SAM. *Story 4424* (4) K. *Strauss 56* (8) NBG.

Taylor 3594, 4214 (2) NBG; *1202* (5) BOL; *3149/35, 4010* (5) NBG; *4325, 4348, 5171, 11137, 11887* (7) NBG; *3957, 5859, 5909, 10616, 11088* (9) NBG. *Theron STE10181* (5) NBG. *Thode STE6082* (5) NBG; *5460, A709, A1135, A2096, STE9494* (7) NBG. *Thomas 27864* (7) BOL. *Thompson 807* (9) NBG; *2894* (10) NBG. *Thompson & Le Roux 224* (8) NBG; *105* (11) NBG; *85* (12) NBG. *Thomson 2143, 3200, 3317,* (7) NBG; *1288* (8) NBG; *303* (NBG) (9), *65, 2663* (10) NBG. *Thorne SAM48847* (8) SAM. *Thorns NBG73539* (7) NBG.

Van Berkel 445 (8) NBG; *259, 446* (9) NBG; *452* (10) NBG. *Van der Merwe 278* (7) NBG; *246* (9) NBG. *Van der Riet s.n* (5) NBG. *Van der Westhuizen s.n.* (10) NBG. *Van Jaarsveld 8444* (8) NBG; *8189* (11) NBG. *Van Niekerk s.n.* (10) BOL. *Van Rooyen, Steyn & de Villiers 497* (9) NBG. *Van Wyk 344, 2059* (7) NBG. *Van Zyl 2776/27* (5) NBG; *3101, 3150, 3191* (7) NBG; *3223, 3302, 3549* (9) NBG. *Visser 44* (7) NBG. *Viviers 3, 1176* (7) NBG; *1568* (9) BOL. *Viviers & Vlok 45, 64* (7) NBG.

Wagener 208 (9) NBG. *Walgate 328* (7) NBG; *BOL22850* (7) BOL. *Walters 2308* (5) NBG; *498, 1219, 1229, 1438, 1781, 2730* (7) NBG; *45* (10) NBG). *Wasserfall 779* (1) NBG; *622, 792* (7). *Wells 2804* (2) K. *Werdermann & Oberdieck 1068* (2) K. *Willems 81* (7) NBG. *Williams 2913, 3343* (7) NBG. *Williamson 3164* (8) BOL; *3795, 5451, 5453* (10) NBG. *Williamson & Williamson 5825* (8) NBG. *Wilman NBG405/37* (7) NBG. *Winkler 152* (5) NBG. *Wolfardt STE10788* (10) NBG. *Woodvine 31* (7) NBG. *Wurts 410, 417, 1204, 1584, 2266* (7) NBG.

Zeyher 5047 (1) BOL, K, NBG, SAM; *1065* (7) NBG. *Zinn SAM62230* (7) SAM.

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Bothalia 37,2: 165–175 (2007)

Name changes in the Old World *Rhus* and recognition of *Searsia* (Anacardiaceae)

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Keywords: Anacardiaceae, nomenclature, *Rhus* L., *Searsia* F.A.Barkley, taxonomy

ABSTRACT

The background to and status of the genus *Searsia* F.A.Barkley (Anacardiaceae) is discussed and reasons given as to why it is the correct name for those Old World species in the *Rhus* complex formely regarded as subgenus *Thezera* (DC.) K.Koch (section *Gerontogeae* Engl.). An annotated list of all the accepted 111 species and 28 further infraspecific taxa in *Searsia* is presented, and where necessary, new combinations are made and types are designated.

INTRODUCTION

When the author revised the southern African species of *Rhus* L., Anacardiaceae, for the *Flora of southern Africa* (Moffett 1993), he stated that he was retaining the species in *Rhus* pending the results of ongoing research on the generic status of this heterogeneous genus. Although he was aware that Barkley had previously published the name *Searsia* for the Old World *Rhus* species, he preferred to follow Brizicky (1963) in treating this group as subgenus *Thezera* (DC.) K.Koch.

Recent phylogenetic analyses using DNA and gene spacers of the *Rhus* complex have shown that *Searsia* is clearly monophyletic and widely separated from *Rhus s. str.* (Miller *et al.* 2001; Yi *et al.* 2004) and there is therefore no further reason not to uphold *Searsia* F.A.Barkley as the correct name for the 'Old World' *Rhus* species.

BRIEF HISTORY OF THE NOMENCLATURE OF THE 'OLD WORLD' *RHUS* SPECIES

The Old World *Rhus* species are found in the Mediterranean, Africa and Asia. Linnaeus included three of these from the Cape in his list of 12 species in *Species plantarum* (Linnaeus 1753). Of the other nine, four have subsequently been retained as *Rhus* L., three as *Toxicodendron* Mill., one as *Cotinus* Mill. and one as *Allophylus* L., (Sapindaceae) [*Index Nominum Genericorum* (*plantarum*) (ING) 2006], epitomizing the heterogeneous nature of *Rhus sensu lato*. The type species of *Rhus* and therefore that which governs the application of *Rhus sensu stricto* is *Rhus coriaria* L., the sumach of southern Europe, Mediterranean region and the near East. With its pinnately compound leaves, drupes with prominent red glandular hairs and resinous mesocarp, it is outwardly markedly different to the species of subgenus *Thezera,* which are characterized by ternate, rarely simple or palmate leaves and drupes pale, glabrous or tomentose with a resinous mesocarp adhering to the bony endocarp.

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The heterogeneity of *Rhus* was recognized early, and Bernhardi (1838) remarked at the end of a paper on *Laurophyllus* Thunb., that the ternate species of *Rhus* from the Cape were different to the true *Rhus* species and seemed to form a distinct genus which one could name *Terminthia* Bernh. Despite this name being used by Wu & Ming (1979) in *Flora Yunnan*, it is illegitimate, as according to Art. 34.1 (b) of the St Louis Code (Greuter *et al.* 2000), it is a provisional name. McNeill & Greuter (pers. comm. October 2006) are of the opinion that Bernhardi's use of the words 'welche man Terminthia nennen könnte' is a clear indication of provisional status and nonacceptance of the name.

The first person to lump all the Old World *Rhus* species together was Engler (1881), who placed them in his new section *Gerontogeae* (the old rhusses), and who soon after provided the first detailed account of the genus in A. & C. De Candolle's *Monographiae phanerogamarum* (Engler 1883). His encyclopaedic treatment of *Rhus* with its four sections, *Trichocarpae*, *Venenatae*, *Gerontogeae* and *Melanocarpae*, formed the foundation by which *Rhus* was measured for the next 60 years until Barkley (1942, 1943, 1950, 1965) criticized the traditional concept of the genus. Engler's use of section *Gerontogeae* was actually illegitimate as it was predated by section *Thezera* of De Candolle (1825).

The name *Searsia* first appeared in a footnote to a key to the genera of the Anacardiaceae where Barkley (1942) stated '*Searsia* n.gen. = (*Rhus*) Section *Gerontogeae.* Named after Paul B. Sears'. Sears (1891–1990), who was to become a renowned stratigraphic palaeontologist, ecologist and head of the Yale School of Botany, was one of a number of botanists thanked by Barkley for encouragement and assistance during the early part of his Ph.D. studies on American *Rhus* species (Barkley 1937).

The above publication, however, was illegitimate as there was no description of the genus and this was corrected the following year when *Searsia* appeared as genus six in *Flora of Texas*, with a full description and including the cultivated *Searsia lancea* (L.f.) F.A.Barkley, a South African species (Barkley 1943). In that publication, Barkley also made the new combination of *S. tomentosa* (L.) F.A.Barkley and designated this species as the type species.

Eight further combinations in *Searsia* were made by Barkley in 1950, and eleven more in a 1965 Iraq publication. In this latter paper, titled 'A criticism of the traditional concept of the genus Rhus', Barkley recognized ten genera in the *Rhus* complex and in place of *Searsia tomentosa,* designated *Searsia pentaphylla* (Jacq.) F.A.Barkley as the type of the genus. In separating the genera of the *Rhus* complex, he chose not to follow Brizicky, who two years previously, in a paper on the generic limits of *Rhus,* preferred to retain the name *Rhus* at genus level and recognized six subgenera, one of which was subgen. *Thezera* (DC.) K.Koch and which included Engler's *Gerontogeae* (Brizicky 1963).

Despite Barkley's criticism, the name *Rhus* has been maintained in all the various African regional floras published subsequently, as well as in the few new species, the latest being *Rhus pygmaea* Moffett (Moffett 1999) and *Rhus gallagheri* Ghaz., (Ghazanfur 2002).

CONFIRMATION OF THE STATUS OF *SEARSIA*

Recent research in the USA on the generic status of *Rhus* has provided conclusive evidence that the 'Old World' species of *Rhus* are sufficiently different to warrant generic status of their own, thus vindicating Barkley. Miller *et al.* (2001) examined the sequences of the internal transcribed spacer region (ITS) of the nuclear ribosomal DNA of six genera in the *Rhus sensu lato* complex in order to determine the monophyly of *Rhus sensu stricto* and to provide insight into the phylogenetic and biogeographical history of the genus. Two species from the Old World, viz. *Searsia ciliata* and *S. quartiniana*, both ex hort., were included. As outgroups in their analysis, *Pistacia vera* and *Schinus molle* were used. The results showed that *Rhus sensu stricto* is monophyletic and that the other genera, *Actinocheita* F.A.Barkley, *Cotinus*, *Malosma* (Nutt.) Raff., *Searsia* and *Toxicodendron* were distinct from *Rhus sensu stricto,* but the relationships between these other genera were not well resolved. Interestingly *Schinus* L., *Searsia* and *Toxicodendron* formed a clade (bootstrap value of 91%). The authors suggested that the use of additional characters such as chloroplast genes, should help to resolve the intergeneric relationships.

This suggestion was followed by Yi *et al.* (2004), who carried out a phylogenetic analysis of the *Rhus* complex using ITS of nuclear ribosomal DNA and chloroplast (*ndh*F and *trn*L-F). Among the species included, but not used in the Miller *et al.* (2001) study, were the southern African *Searsia lancea, S. leptodictya, S. pyroides* and *S. undulata,* all ex hort. The phylogenetic analysis of the ITS, the chloroplast and the combined ITS and chloroplast datasets confirmed the monophyly of *Rhus sensu* Barkley (1937) and that *Searsia* from Africa was monophyletic and distinct from the *Rhus* clade. The ITS data also showed that *Searsia lancea, S. leptodictya* and *S. undulata* formed a clade, which was sister to the clade composed of *S. ciliata, S. pyroides* and *S. quartiniana.* A chronogram indicating diversion times compiled by these authors based on the maximum likelihood tree of the combined ITS and cpDNA data showed that *Searsia undulata* diverged 55 Ma, *Rhus* 49 Ma and *R. coriaria* 24 Ma.

SEARSIA F.A.BARKLEY: SPECIES AND TYPES

Barkley's original designation of *Searsia tomentosa* as the type species of the genus (Barkley 1943), and subsequent replacement by *S. pentaphylla* (Barkley 1965) requires some explanation, and I am indebted to Prof. John McNeill of Ontario and Edinburgh for clarifying the issue.

Article 7.4 of the Code states 'A new name formed from a previously published legitimate name (stat. nov., comb. nov.) is, in all circumstances, typified by the type of the basionym, even though it may have been applied erroneously to a taxon now considered not to include the type'. As Barkley, 1943, cited *Rhus* sect. *Gerontogeae* Engl. (1881) as a synonym of his new genus, his designation of *S. tomentosa* as the type was superfluous, as the type of *Searsia* is the type of sect. *Gerontogeae.* Section *Gerontogeae* is, however, illegitimate as Engler acknowledged in his publication that it was based on the earlier sect. *Thezera* DC. (1825). As Engler did not indicate a type for sect. *Gerontogeae*, according to Art. 7.5, *Searsia* is automatically typified by the type of sect. *Thezera.* Neither De Candolle nor Koch (1853), who treated *Thezera* as a subgenus, designated types and it was left to Brizicky (1963) to choose a lectotype, viz. *Rhus pentaphylla* (Jacq.) Desf., which explains why Barkley accepted this in 1965. Despite this, ING (2006), however, still cites *R. tomentosa* L. as the type of *Searsia.*

The following list is based on research undertaken on the taxonomy of all the Old World *Rhus* species when revising *Rhus* in southern Africa between 1976 and 1992 (Moffett 1993), and on the relevant literature since then. The few differences between this list and that of the accepted names for sub-Saharan Africa (Klopper *et al.* 2006) are intentional. Based on the notes made when the author visited many European herbaria in 1982 and correspondence with respected taxonomists, types have been designated for those taxa as yet untypified.

Searsia *F.A.Barkley* in Flora of Texas 3: 104 (1943).

Rhus subgen. *Thezera* (DC.) K.Koch., Hortus dendrologicus: 197 (1853); *Rhus* sect. *Thezera* DC. (1825); *Rhus* sect. *Gerontogeae* Engl. 379: (1881) nom. illeg.

Type: *Searsia pentaphylla* (Jacq.) F.A.Barkley: 57 (1965). Basionym *Rhus pentaphylla* (Jacq.) Desf. lecto., designated by Brizicky: 63 (1963); *Rhamnus pentaphylla* Jacq.: 27 (1767); *Rhamnus Siculus pentaphyllos* Boccone: 43, t. 21, (1674).

Searsia acocksii *(Moffett) Moffett*, comb. nov.

Rhus acocksii Moffett in South African Journal of Botany 54: 172 (1988). Type: Eastern Cape, Lusikisiki District, southern edge of Msikaba Gorge, *Acocks 13250* (PRE, holo.!).

South Africa.

Searsia acuminatissima *(R.Fern. & A.Fern.) Moffett*, comb. nov.

Rhus acuminatissima R.Fern. & A.Fern. in Boletim Sociedade Broteriana, sér. 2, 38: 183 (1965b). Type: Malawi, Mulanje Mtn, Likabula, *Clements 121* (FHO, holo.).

Malawi, Mozambique.

Searsia albida *(Schousb.) Moffett*, comb. nov.

Rhus albida Schousb., Iagttagelser Vextriget i Marokko: 142 (1800). Type: Marocco [Morocco], *Schousboe s.n.* (C!, lecto., here designated).

Algeria, Libya, Morocco.

Searsia albomarginata *(Sond.) Moffett*, comb. nov.

Rhus albomarginata Sond. in Flora capensis 1: 519 (1860). Type: Eastern Cape, Slaaykraal, *Burke s.n.* [K!, lecto., designated by Moffett: 88 (1993)].

South Africa.

Searsia anchietae *(Fiçalho & Hiern ex Hiern) Moffett*, comb. nov., forma **anchietae**

Rhus anchietae Fiçalho & Hiern ex Hiern, Catalogue of Welwitsch's African plants 1,1: 184 (1896). Type: Angola, Huilla, Monhino, *Welwitsch 4424* (LISU!, ♂, lecto., here designated).

Angola, Malawi, Tanzania, Uganda, Democratic Republic of the Congo, Zambia.

Searsia anchietae *(Fiçalho & Hiern ex Hiern) Moffett* forma **mendonçae** *(Meikle) Moffett*, comb. nov.

Rhus anchietae Fiçalho & Hiern ex Hiern forma *mendonçae* (Meikle) R.Fern. in Garcia de Orta (Lisboa) 14,3: 360 (1966). *R. mendonçae* Meikle: 284 (1952). Type: Angola, Benguela, Rio Quito, prox. de Quipeio, *Exell & Mendonça 1877* (COI, holo.!).

Angola.

Searsia anchietae *(Fiçalho & Hiern ex Hiern) Moffett* forma **suffruticosa** *(Meikle) Moffett*, comb. nov.

Rhus anchietae Fiçalho & Hiern ex Hiern forma *suffruticosa* (Meikle) R.Fern. in Garcia de Orta 14,3: 362 (1966). *R. suffruticosa* Meikle: 287 (1952). Type: Zambia, Mwinilunga District, near Dobeka Bridge, *Milne-Redhead 3609* (K, holo.!).

Angola, Democratic Republic of the Congo (DRC), Zambia.

Searsia angolensis *(Engl.) Moffett*, comb. nov., forma **angolensis**

Rhus angolensis Engl. in Monographiae phanerogamarum 4: 448 (1883). Type: Angola, Huilla, Catumba, Lopolo, *Welwitsch 4429* [G-DC (Mon. Phan.), holo.!].

Angola.

Searsia angolensis *(Engl.) Moffett* forma **glabrescens** *(R.Fern.) Moffett*, comb. nov.

Rhus angolensis Engl. forma *glabrescens* R.Fern. in Garcia de Orta (Lisboa) 14,3: 366 (1966). Type: Angola, Cuanza Sul, Cela, *Barbosa & R. Correia 8873* (LISC, holo.!).

Angola.

Searsia angustifolia *(L.) F.A.Barkley* in Monographs of the Biological Society of Iraq 3: 54 (1965).

Rhus angustifolia L.: 267 (1753). Type: Aethiopia (Africa). *Herb. LINN 378.21* [LINN!, lecto., designated by Moffett: 100 (1993)].

South Africa.

Searsia arenaria *(Engl.) Moffett,* comb. nov.

Rhus arenaria Engl. in Botanische Jahrbücher 32: 132 (1903). Type: Angola, Huilla, alongside Nene River, *Dekindt 685* [P!, ♂, neo., designated by R.Fern.: 363 (1966)].

Angola.

Searsia aucheri *(Boiss.) Moffett*, comb. nov.

Rhus aucheri Boiss., Diagnoses plantarum orientalium novarum 2: 5 (1843). Type: Mascate [Muscat & Oman], *Aucher-Eloy 4324* [G (Herb. Boiss.!), lecto., here designated)].

Arabia (Sultanate of Oman).

Searsia batophylla *(Codd) Moffett*, comb. nov.

Rhus batophylla Codd in Bothalia 6: 539 (1956). Type: Eastern Transvaal [Mpumalanga], Steelpoort, Mooihoek Chrome Mine, *Codd & Dyer 7699* (PRE, holo.!).

South Africa.

Searsia blanda *(Meikle) Moffett*, comb. nov., forma **blanda**

Rhus blanda Meikle in Boletim Sociedade Broteriana, sér. 2, 26: 286 (1952). Type: Angola, Benguela, Nova Lisboa and Texeira da Silva, *Exell & Mendonça 1822* (COI, holo.!).

Angola.

Searsia blanda *(Meikle) Moffett* forma **exelliana** *(Meikle) Moffett*, comb. nov.

Rhus blanda Meikle forma *exelliana* (Meikle) R.Fern. in Garcia de Orta 14,3: 371 (1966). *R. exelliana* Meikle: 102 (1954). Type: Angola, Bié, Rio Cubango, Vila da Ponte, *Gossweiler 3648* (BM, holo.!).

Angola.

Searsia bolusii *(Sond. ex Engl.) Moffett*, comb. nov.

Rhus bolusii Sond. ex Engl. in Monographiae phanerogamarum 4: 436 (1883). Type: Eastern Cape, Graaff-Reinet, Cave Mountain, *Bolus 737* (S, holo.!).

South Africa.

Searsia brenanii *(Kokwaro) Moffett*, comb. nov.

Rhus brenanii Kokwaro in Kew Bulletin 34: 754 (1980). Type: Tanzania, Rungwe District, Siwago, Pangundutani, *Brenan & Greenway 8202* (EA, holo.).

Tanzania.

Searsia burchellii *(Sond. ex Engl.) Moffett*, comb. nov.

Rhus burchellii Sond. ex Engl. in Monographiae phanerogamarum 4: 412 (1883). Type: Northern Cape, confluence of Vaal and Orange Rivers, *Burchell 1722* (K, holo.!).

Lesotho, Namibia, South Africa.

Searsia carnosula *(Schönland) Moffett*, comb. nov.

Rhus carnosula Schönland in Bothalia 3: 41 (1930). Type: Eastern Cape, Gekau, *Drège 5569β* [P!, lecto., designated by Moffett: 33 (1993)].

South Africa.

Searsia chirindensis *(Baker f.) Moffett*, comb. nov.

Rhus chirindensis Baker f. in Botanical Journal of the Linnean Society 40: 49 (1911). Type: Zimbabwe, near Chirinda, *Swynnerton 168* (BM, holo.!).

Mozambique, South Africa, Swaziland, Zimbabwe.

Searsia ciliata *(Licht. ex Schult.) A.J.Mill.* in A.J. Mill et al. in International Journal of Plant Sciences 162: 1403 (2001).

Rhus ciliata Licht. ex Schult. in L.: 661 (1820). Type: Northern Cape, Grootte Rivier Poort, *Liechtenstein in Herb. Willd. 6016* [B (WILLD.), holo.!].

Botswana, Namibia, South Africa.

Searsia crenata *(Thunb.) Moffett*, comb. nov.

Rhus crenata Thunb. in Phytographische Blätter: 28 (1803). Type: Cape of Good Hope, *Thunberg in Herb. Thunberg 7321* [UPS!, *Rhus crenatum* α , lecto., designated by Moffett: 75 (1993)].

South Africa.

Searsia crenulata *(A.Rich.) Moffett*, comb. nov.

Rhus crenulata A.Rich., Tentamen Florae Abyssinica 4: 142 (1847). Type: Ethiopia, Tchéleukote, *Petit ex Herb. Rich.* (P!, lecto., *R. crenulata nob.*, here designated).

Ethiopia.

Searsia cuneifolia *(L.f.) F.A.Barkley* in Monographs of the Biological Society of Iraq 3: 54 (1965).

Rhus cuneifolia L.f.: 183 (1781). Type: Cape of Good Hope, *Thunberg in Herb. Thunberg 7323* [UPS!, lecto., designated by Moffett: 92 (1993)].

South Africa.

Searsia dentata *(Thunb.) F.A.Barkley* in Monographs of the Biological Society of Iraq 3: 54 (1965).

Rhus dentata Thunb.: 52 (1794). Type: Cape of Good Hope, *Thunberg in Herb. Thunberg 7325* [UPS!, lecto., designated by R.Fern.: 124 (1967)].

Lesotho, Mozambique, South Africa, Swaziland, Zimbabwe.

Searsia discolor *(E.Mey. ex Sond.) Moffett,* comb. nov.

Rhus discolor E.Mey. ex Sond. in Flora capensis 1: 507 (1860). Type: Eastern Cape, Katberg, *Drège 3449* [S!, lecto., designated by Moffett: 52 (1993)].

Lesotho, South Africa, Swaziland.

Searsia dissecta *(Thunb.) Moffett,* comb. nov.

Rhus dissecta Thunb. in Phytographische Blätter 29 (1803). Type: Cape of Good Hope. *Masson in Herb. Thunberg 7330* (UPS, holo.!).

South Africa.

Searsia divaricata *(Eckl. & Zeyh.) Moffett*, comb. nov.

Rhus divaricata Eckl. & Zeyh., Enumeratio plantarum Africae australis extratropicae 1: 146 (1836). Eastern Cape, Tambukiland, Klipplaatrivier, *Ecklon & Zeyher 1106* [S!, lecto., designated by Moffett: 53 (1993)].

Lesotho, South Africa.

Searsia dracomontana *(Moffett) Moffett*, comb. nov.

Rhus dracomontana Moffett in Flora of southern Africa 19,3: 41 (1993). Type: Natal [KwaZulu-Natal], Van Reenen, *Schlechter 6754* (BOL, holo.!).

South Africa.

Searsia dregeana *(Sond.) Moffett*, comb. nov.

Rhus dregeana Sond. in Flora capensis 1: 516 (1860). Type: Eastern Cape, Stormberg, Mooiplaats, *Drège s.n.* [S!, lecto., designated by Moffett: 65 (1993)].

Lesotho, South Africa.

Searsia dumetorum *(Exell) Moffett*, comb. nov.

Rhus dumetorum Exell in Journal of Botany 66, Supplementum Polypetalum: 93 (1928). Type: Angola, Bié, Cassuango, Cuiriri, *Gossweiler 3692* (BM, holo.!).

Angola.

Searsia engleri *(Britten) Moffett*, comb. nov.

Rhus engleri Britten in Journal of Botany 38: 316 (1900). Type: Transvaal [Limpopo], Klippan, *Rehmann 5325* [Z!, lecto., designated by Moffett: 61 (1993)].

South Africa.

Searsia erosa *(Thunb.) Moffett*, comb. nov.

Rhus erosa Thunb., Flora capensis 2: 212 (1818). Type: Cape of Good Hope, *Sparrman ? in Herb. Thunberg 7333* [UPS!, lecto., designated by Moffett: 69 (1993)].

Lesotho, South Africa.

Searsia fanshawei *(R.Fern. & A.Fern.) Moffett*, comb. nov.

Rhus fanshawei R.Fern. & A.Fern. in Boletim Socicdade Broteriana, sér. 2, 38: 185 (1965b). Type: Zambia, Nkloemfumu, *Fanshawe 4767* (K, holo.!).

Zambia.

Searsia fastigata *(Eckl. & Zeyh.) Moffett*, comb. nov.

Rhus fastigata Eckl. & Zeyh., Enumeratio plantarum Africanae australis extratropicae 2: 146 (1836). Type: Eastern Cape, Albany and Uitenhage, *Ecklon & Zeyher 1107* [S!, lecto., designated by Moffett: 51 (1993)].

South Africa.

Searsia flexicaulis *(Baker) Moffett*, comb. nov.

Rhus flexicaulis Baker in Kew Bulletin 108: 316 (1895). Type: southern Arabia, Hadhramaut, *Hirsch 153* (K, holo.!).

Arabia, Egypt, Sudan, Yemen.

Searsia gallagheri *(Ghaz.) Moffett*, comb. nov.

Rhus gallagheri Ghaz. in Kew Bulletin 57: 492 (2002). Type: Sultanate of Oman, Dhofar, hills above Sharbitat, *Hughes & Gallagher 7895/2* (K, holo.).

Arabia (Sultanate of Oman).

Searsia gerrardii *(Harv. ex Engl.) Moffett*, comb. nov.

Rhus gerrardii (Harv. ex Engl.) Diels in Botanische Jahrbücher 24: 588 (1898). *R. viminalis* Vahl var. *gerrardii* Harv. ex Engl.: 442 (1883). Type: Natal [KwaZulu-Natal], *Gerrard & McKen 1396* [K!, lecto., designated by R.Fern.: 131 (1967)].

South Africa, Swaziland.

Searsia glauca *(Thunb.) Moffett*, comb. nov.

Rhus glauca Thunb. in Phytographische Blätter: 27 (1803). Type: Cape of Good Hope. *Thunberg in Herb. Thunberg 7339* [UPS!, lecto., designated by Moffett: 82 (1993)].

South Africa.

Searsia glaucescens *(A.Rich.) Moffett*, comb. nov.

Rhus glaucescens A.Rich., Tentamen Florae Abyssinica 1: 143 (1847). Type: Ethiopia, Crescit in provincie Choa, *A. Petit* (P, holo.).

Ethiopia, West, Central and East Africa.

Searsia glutinosa *(Hochst. ex A.Rich.) Moffett* subsp. **abyssinica** *(Oliv.) Moffett*, comb. nov.

Rhus abyssinica Oliv. in Flora of tropical Africa 1: 438 (1868). Type: Ethiopia, Tigray Region, Gennis, near Adowa, *Schimper 259* (K, holo.!).

Eritrea, Ethiopia, Sudan.

Searsia glutinosa *(Hochst. ex A.Rich.) Moffett*, comb. nov., subsp. **glutinosa**

Rhus glutinosa Hochst. ex A.Rich., Tentamen Florae Abyssinica 1: 144 (1847). Type: Ethiopia, Gunder Region, near Tschenausa, *Schimper II: 851* [P!, lecto., designated by Gilbert: 572 (1986b)].

Ethiopia.

Searsia glutinosa *(Hochst. ex A.Rich.) Moffett* subsp. **neoglutinosa** *(M.G.Gilbert) Moffett*, comb. nov.

Rhus neoglutinosa M.G.Gilbert in Nordic Journal of Botany 6:139 (1986a). Type: Ethiopia, Shewa Region, between Addis Abeba and Ambo, near Menegesha Village, *Jackson 712* (K, holo.!).

Ethiopia.

Searsia gracilipes *(Exell) Moffett*, comb. nov.

Rhus gracilipes Exell in Journal of Botany 66, Supplementum Polypetalum: 93 (1928). Type: Angola, Benguela, Caconda, prox. de Bissapa, *Gossweiler 4269* (BM, holo.!).

Angola.

Searsia gracillima *(Engl.) Moffett* var. **glaberrima** *(Schönland) Moffett*, comb. nov.

Rhus gracillima Engl. var. *glaberrima* Schönland in Bothalia 3: 86 (1930). Type: Eastern Transvaal [Mpumalanga], Witbank District, hills near Wilge River, *Schlechter 3746* (Z, holo.!).

South Africa.

Searsia gracillima *(Engl.) Moffett*, comb. nov., var. **gracillima**

Rhus gracillima Engl. in Monographiae phancrogamarum 4: 445 (1883). Type: Transvaal [Limpopo], Boshveldt, between Menaar's Farm and Elands River, *Rehmann 4882* [Z!, lecto., designated by Moffett: 113 (1993)].

South Africa.

Searsia grandidens *(Harv. ex Engl.) Moffett*, comb. nov.

Rhus grandidens Harv. ex Engl. in Monographiae phanerogamarum. 4: 440 (1883). Type: Natal [KwaZulu-Natal], *Gerrard & McKen 1399* (K, holo.!).

South Africa, Swaziland.

Searsia grossireticulata *(Van der Veken) Moffett*, comb. nov.

Rhus grossireticulata Van der Veken in Bulletin Jardin Botanique État Bruxelle 29: 241 (1959). Type: Democratic Republic of the Congo, Haut-Katanga, Kisenge-Kapolo, *P. Duvigneaud 2336* (BRLU, holo.!).

Democratic Republic of the Congo.

Searsia gueinzii *(Sond.) F.A.Barkley* in Lilloa 23: 253 (1950).

Rhus gueinzii Sond.: 515 (1860). Type: Natal [KwaZulu-Natal], Port Natal [Durban], *Gueinzius s.n.* [TCD!, lecto., designated by Moffett: 76 (1993)].

Mozambique, South Africa, Swaziland, Zimbabwe.

Searsia harveyi *(Moffett) Moffett*, comb. nov.

Rhus harveyi Moffett in Flora of southern Africa 19,3: 95 (1993). Type: Natal [KwaZulu-Natal], Zululand, *Gerrard & McKen 1406* (TCD, holo.!).

South Africa, Swaziland.

Searsia horrida *(Eckl. & Zeyh.) Moffett*, comb. nov.

Rhus horrida Eckl. & Zeyh., Enumeratio plantarum Africanae australis extratropicae 2: 146 (1836). Type: Northern Cape, Namaqualand, Kamiesberg, *Ecklon & Zeyher 1135* [S!, lecto., designated by Moffett: 115 (1993)].

South Africa.

Searsia humpatensis *(Meikle) Moffett*, comb. nov., forma **humpatensis**

Rhus humpatensis Meikle in Boletim Sociedade Broteriana, sér. 2, 26: 284 (1952). Type: Angola, Huila, Humpata, *Carriso & Mendonça 609* (COI, holo.!).

Angola.

Searsia humpatensis *(Meikle) Moffett* forma **subglabra** *(R.Fern.) Moffett*, comb. nov.

Rhus humpatensis Meikle forma *subglabra* R.Fern. in Garcia da Orta (Lisboa) 14,3: 367 (1966). Type: Angola, Sá da Bandeira, Fenda da Tunda-Vala, *R. Santos & Henriques 1143* (LISC, holo.!).

Angola.

Searsia incisa *(L.f.) F.A.Barkley* var. **effusa** *(Presl) Moffett*, comb. nov.

Rhus incisa L.f. var. *effusa* (Presl) R.Fern. in Boletim Sociedade Broteriana, sér. 2, 42: 128 (1967). Type: Eastern Cape, *Ecklon & Zeyher 1111* (PR, holo.–photo!).

South Africa.

Searsia incisa *(L.f.) F.A.Barkley* var. **incisa** in Monographs of the Biological Society of Iraq 3: 54 (1965).

Rhus incisa L.f.: 183 (1781). Type: Western Cape, near Paardeberg, *Thunberg in Herb. Thunberg 7341* [UPS!, lecto., designated by R.Fern.: 128 (1967)].

South Africa.

Searsia keetii *(Schönland) Moffett*, comb. nov.

Rhus keetii Schönland in Bothalia 3: 87 (1930). Type: Eastern Transvaal [Mpumalanga], Lydenburg District, Klip River, Steelpoort Park, *Keet 1435* (GRA, holo.!).

South Africa.

Searsia kirkii *(Oliv.) Moffett*, comb. nov.

Rhus kirkii Oliv. in Flora of tropical Africa 1: 439 (1868). Type: Zimbabwe, near Victoria Falls, *Kirk s.n.* (K, holo.!).

Angola, Democratic Republic of the Congo, Namibia, Zambia, Zimbabwe.

Searsia krebsiana *(Presl ex Engl.) Moffett*, comb. nov.

Rhus krebsiana Presl ex Engl. in Monographiae phanerogamarum 4: 409 (1883). Type: Cape of Good Hope, *Krebs s.n.* [G-DC (Mon. Phan.), holo.!].

South Africa.

Searsia kwangoensis *(Van der Veken) Moffett*, comb. nov.

Rhus kwangoensis (Van der Veken) Kokwaro in Kew Bulletin 34: 753 (1980). *R. kirkii* Oliv. var. *kwangoensis* Van der Veken: 242 (1959). Type: Democratic Republic of the Congo, Lukuni, *Callens 3015* (BR, holo.!).

Democratic Republic of the Congo, Uganda.

Searsia kwazuluana *(Moffett) Moffett*, comb. nov.

Rhus kwazuluana Moffett in Flora of southern Africa 19,3: 71 (1993). Type: Natal [KwaZulu-Natal], St Lucia, Mbomvini, *MacDevette 353* (PRE, holo.!).

South Africa.

Searsia laevigata *(L.) F.A.Barkley* var. **laevigata** forma **cangoana** *(Moffett) Moffett*, comb. nov.

Rhus laevigata L. forma *cangoana* Moffett in Flora of southern Africa 19,3: 38 (1993). Type: Western Cape, Oudtshoorn District, Boomplaas, *Moffett 118* (PRE, holo.!).

South Africa.

Searsia laevigata *(L.) F.A.Barkley* var. **laevigata** forma **laevigata** in Monographs of the Biological Society of Iraq 3: 54 (1965).

Rhus laevigata L.: 1672 (1763). Type: Cape of Good Hope, *Herb. LINN 378-23* [LINN!, lecto., designated by R.Fern.: 129 (1967)].

South Africa.

Searsia laevigata *(L.) F.A.Barkley* var. **villosa** *(L.f.) Moffett*, comb. nov.

Rhus laevigata L. var. *villosa* (L.f.) R.Fern. in Boletim Sociedade Broteriana, sér. 2, 42: 130 (1967). Type: Cape of Good Hope, *Herb. LINN 378.26* [LINN!, lecto., designated by Schönland: 17 (1930)].

South Africa.

Searsia lancea *(L.f.) F.A.Barkley* in Flora of Texas 3: 104 (1943).

Rhus lancea L.f.: 184 (1781). Type: Cape of Good Hope, *Thunberg* in *Herb. Thunberg 7348β* [UPS!, lecto., designated by Moffett: 24 (1984)].

Botswana, Lesotho, Namibia, South Africa, Zimbabwe.

Searsia leptodictya *(Diels) T.S.Yi, A.J.Mill. & J.Wen* forma **leptodictya** in Molecular Phylogenetics & Evolution 33: 861 (2004).

Rhus leptodictya Diels: 86 (1907). Type: Transvaal [Gauteng], Pretoria, *Reck 13* [GRA!, neo., designated by R.Fern. & A.Fern.: 699 (1965a)].

Angola, Mozambique, Namibia, South Africa, Swaziland, Zimbabwe.

Searsia leptodictya *(Diels) T.S.Yi, A.J.Mill. & J.Wen* forma **pilosa** *(R.Fern. & A.Fern.) Moffett*, comb. nov.

Rhus leptodictya Diels forma *pilosa* R.Fern. & A.Fern.: 187 (1965b). Type: Zimbabwe, Ndanga, *Armitage 104/55* (SRGH, holo.!).

Malawi, Zimbabwe.

Searsia longipes *(Engl.) Moffett* var. **elgonensis** *(Kokwaro) Moffett*, comb. nov.

Rhus longipes Engl. var. *elgonensis* Kokwaro in Kew Bulletin 34: 754 (1980). Type: Kenya, Mt Elgon, *T.H.E. Jackson 312a* (EA, holo.).

Kenya, Uganda.

Searsia longipes *(Engl.) Moffett*, comb. nov., var. **longipes**

Rhus longipes Engl. in Monographiae phanerogamarum 4: 431 (1883). Type: Angola, Cuanze Norte, Carengwe, Queta, *Welwitsch 4413* [G-DC (Mon. Phan.), holo.!].

From Sierra Leone in the west to Ethiopia in the east and as far south as Angola and Zimbabwe.

Searsia longipes *(Engl.) Moffett* var. **schinoides** *(R. Fern.) Moffett*, comb. nov.

Rhus longipes Engl. var. *schinoides* R.Fern. in Memoire Junta Investigado da Ultramar, sér. 2, 38: 39 (1962). Type: Zambia, 13 km NW of Abercorn, *Hutchinson & Gillett 4010* (K, holo.!).

Kenya, Tanzania, Zambia.

Searsia longispina *(Eckl. & Zeyh.) Moffett*, comb. nov.

Rhus longispina Eckl. & Zeyh., Enumeratio plantarum Africae australis extratropicae 2: 148 (1836). Type: Eastern Cape, *Ecklon & Zeyher 1116 p.p.* [SAM!, lecto., designated by Moffett: 83 (1993)].

South Africa.

Searsia lucens *(Hutch.) Moffett*, comb. nov.

Rhus lucens Hutch., A botanist in southern Africa: 480 (1946). Type: Zimbabwe, near Victoria Falls, *Hutchinson & Gillett 3473* (K, holo.!).

Botswana, Namibia, Zimbabwe.

Searsia lucida *(L.) F.A.Barkley* forma **elliptica** *(Sond.) Moffett*, comb. nov.

Rhus lucida L. forma *elliptica* (Sond.) Moffett in Flora of southern Africa 19,3: 81 (1993). *R. elliptica* Sond.: 517 (1860). Type: Western Cape, mouth of Onrustrivier, *Zeyher 2248* [K!, lecto., designated by Moffett: 81 (1993)].

South Africa.

Searsia lucida *(L.) F.A.Barkley* forma **lucida** in Monographs of the Biological Society of Iraq 3:54 (1965).

Rhus lucida L.: 267 (1753). Type: Cape of Good Hope, *Herb. Cliff. III, 6á(32)* [BM!, lecto., designated by Moffett: 79 (1993)].

South Africa, Zimbabwe.

Searsia lucida *(L.) F.A.Barkley* forma **scoparia** *(Eckl. & Zeyh.) Moffett*, comb. nov.

Rhus lucida L. forma *scoparia* (Eckl. & Zeyh.) Moffett in Flora of southern Africa 19,3: 79 (1993). *R. scoparia* Eckl. & Zeyh.: 149 (1836). Type: Eastern Cape, *Ecklon & Zeyher 1122* [SAM!, lecto., designated by Moffett: 79 (1993)].

South Africa.

Searsia magalismontana *(Sond.) Moffett* subsp. **coddii** *(R.Fern. & A. Fern.) Moffett*, comb. nov.

Rhus magalismontana Sond. subsp. *coddii* (R.Fern. & A.Fern.) Moffett in Flora of southern Africa 19,3: 57 (1993). *R. coddii* R.Fern. & A.Fern.: 251 (1965c). Type: Northern Transvaal [Limpopo], Venda, Sambandou, *Codd 6902* (PRE, holo.!).

South Africa.

Searsia magalismontana *(Sond.) Moffett*, comb. nov., subsp. **magalismontana**

Rhus magalismontana Sond. in Flora capensis 1: 510 (1860). Type: Transvaal [Gautcng], Magaliesberg, Crocodile River, *Zeyher 341* (S, holo.!).

Botswana, South Africa.

Searsia magalismontana *(Sond.) Moffett* subsp. **trifoliolata** *(Baker f.) Moffett*, comb. nov.

Rhus magalismontana Sond. subsp. *trifoliolata* (Baker f.) Moffett in Flora of southern Africa 19,3: 59 (1993). *R. trifoliolata* Baker f.: 429 (1899). Type: Zimbabwe, Bulawayo, *Rand 66* (BM, holo.!).

South Africa, Zimbabwe.

Searsia maricoana *(Moffett) Moffett*, comb. nov.

Rhus maricoana Moffett in Flora of southern Africa 19,3: 110 (1993). Type: Transvaal [North-West], Zeerust, Marico chrome mine, *Moffett 3566* (PRE, holo.!).

South Africa.

Searsia marlothii *(Engl.) Moffett*, comb. nov.

Rhus marlothii Engl. in Botanische Jahrbücher 10: 37 (1888). Type: South West Africa [Namibia], Otjimbingue, *Marloth 1394* [K!, lecto., designated by Moffett: 61 (1993)].

Namibia.

Searsia montana *(Diels) Moffett*, comb. nov.

Rhus montana Diels in Botanische Jahrbücher 40: 86 (1907). Type: Eastern Cape, Transkei, near Engcobo, *Bolus 8837* [K!, lecto., designated by R.Fern.: 131 (1967)].

Lesotho, South Africa.

Searsia monticola *(Meikle) Moffett*, comb. nov.

Rhus monticola Meikle in Memoirs of the New York Botanical Garden 8: 242 (1953b). Type: Malawi, Mulanje Mtn, Luchenya Plateau, *Brass 16656* (K, holo.!).

Malawi.

Searsia mysorensis *(G.Don) Moffett*, comb. nov.

Rhus mysorensis G.Don, A general system of gardening and botany 2: 74 (1832). Type: India, *Herb. Wallich 997* [K (Wallich)!, sheet with 4 elements: a, *Rhus indicum* nob. from the Governor's Garden, Jan. 17, 1804; b, *Rhus mysorensis* ex herbareo Heyneano in Horto Botanico Calcutta; b here designated as neo.]*.

India.

Searsia natalensis *(Bernh. ex Krauss) F.A.Barkley* in Lilloa 23: 253 (1950).

Rhus natalensis Bernh. ex Krauss: 349 (1844)**. Type: Durban, forests around Natal Bay, *Krauss 395* [TUB!, lecto., designated by Moffett: 75 (1993)].

Mozambique, Réunion, South Africa.

Searsia nebulosa *(Schönland) Moffett*, comb. nov., forma **nebulosa**

Rhus nebulosa Schönland in Bothalia 3: 33 (1930). Type: Natal [KwaZulu-Natal], near Durban, *Schlechter 2858* [GRA!, lecto., designated by Moffett: 39 (1993)].

Mozambique, Réunion, South Africa.

Searsia nebulosa *(Schönland) Moffett* forma **pubescens** *(Moffett) Moffett*, comb. nov.

Rhus nebulosa Schönland forma *pubescens* Moffett in Flora of southern Africa 19,3: 40 (1993). Type: Eastern Cape, Alexandria Forest, Olifantshoek, *Johnson 649* (PRE, holo.!).

South Africa.

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* No specimen annotated by G.Don could be found, thus requiring the designation of a neotype. Both a and b on the above sheet are almost identical and any one could have been chosen.

** Bernhardi is sometimes cited as the author of the new names based on Krauss's specimens. In this particular case, however, Krauss himself should be recognized as he used the words 'in specimen meo' when citing *Cissus natalensis* Bernh. olim in sched.

Searsia nitida *(Engl.) Moffett*, comb. nov.

Rhus nitida Engl. in Monographiae phanerogamarum 4: 434 (1883). Type: Angola, Cuanza Norte, entre Mutoto e Candumba, Pungo Andongo, *Welwitsch 4417* [G-DC (Mon. Phan.), holo.!].

Angola.

Searsia obtusata *(Engl.) Moffett*, comb. nov.

Rhus obtusata (Engl.) Meikle in Boletim Sociedade Broteriana, sér. 2, 26: 287 (1952). *R. villosa* L.f. var. *obtusata* Engl.: 425 (1883). Type: Angola, Moçamedes, Base da Serra da Chela, *Welwitsch 4419* [G-DC (Mon. Phan.), holo.!].

Angola.

Searsia ochracea *(Meikle) Moffett*, comb. nov., var. **ochracea**

Rhus ochracea Meikle in Kew Bulletin 8: 107 (1953a). Type: Malawi, Fort Hill, *Whyte s.n.* (K, holo.!).

Malawi, Tanzania, Zambia.

Searsia ochracea *(Meikle) Moffett* var. **saxicola** *(R.Fern. & A.Fern.) Moffett*, comb. nov.

Rhus ochracea Meikle var. *saxicola* R.Fern. & A.Fern. in Boletim Sociedade Broteriana, sér. 2, 38: 189 (1965b). Type: Zambia, Mpika, Muchinga Escarpment, *Angus 865* (K, holo.!).

Zambia.

Searsia pallens *(Eckl. & Zeyh.) Moffett,* comb. nov.

Rhus pallens Eckl. & Zeyh., Enumeratio plantarum africanae australis extratropicae 2: 147 (1836). Type: Eastern Cape, Uitenhage, *Ecklon & Zeyher 1114* [SAM!, lecto., designated by Moffett: 85 (1993)].

Lesotho, South Africa.

Searsia paniculata *(Wall. ex G.Don) Moffett*, comb. nov.

Rhus paniculata Wall. ex G.Don, A general system of gardening and botany 2: 73 (1832). Type: Burma [Myanmar], Yenanghuen, *Herb. Wallich 993* [K (Wallich)!, sheet with two elements: right hand element, ♂, Sept. 1826, neo., here designated]*.

Bhutan, China, India, Myanmar.

Searsia parviflora *(Roxb.) F.A.Barkley* in Lilloa 23: 253 (1950).

Rhus parviflora Roxb.: 100 (1832). Type: Nepal & Hort. Calcutta, *Roxburgh* (BM!, sheet marked *Rhus parviflorum* Roxb., Patria Nepaul, *HB1815*, lecto., here designated].

India, Nepal.

Searsia pendulina *(Jacq.) Moffett*, comb. nov.

Rhus pendulina Jacq., Plantarum rariorum horti caesarei schoenbrunnensis 4: 24, t. 449 (1804). Type: ex hort Schönbrunn, *Jacquin s.n.* [M!, lecto., designated by Moffett: 91 (1993)].

Namibia, South Africa.

Searsia pentaphylla *(Jacq.) F.A.Barkley* in Monographs of the Biological Society of Iraq 3:57 (1965).

Rhamnus pentaphylla Jacq.: 27 (1767), (*Rhamnus Siculus pentaphyllos* Boccone: 43, t. 21, 1674). Type: Sicily, *Boccone s.n. ex Dr Jacquin* (BM!, sheet 92, lecto., here designated.).

Algeria, Israel, Morocco, Palestine, Sicily.

Searsia pentheri *(Zahlbr.) Moffett*, comb. nov.

Rhus pentheri Zahlbr. in Annalen des Naturhistorischen Museums in Wien 15,1: 52 (1900). Type: Natal [KwaZulu-Natal], Colossa, *Krook sub. Penther 2290* (W, holo.!).

Mozambique, South Africa, Swaziland.

* Don cited '(Wall. mss. in herb. Lin. soc.)'. No Wallich specimen was found in LINN, and as no other specimens annotated by him could be traced, a neotype had to be chosen.

Searsia pondoensis *(Schönland) Moffett*, comb. nov.

Rhus pondoensis Schönland in Bothalia 3: 95 (1930). Type: Natal [KwaZulu-Natal], near Murchison, *J. Medley Wood 3002* (SAM, holo.!).

South Africa, Swaziland.

Searsia populifolia *(E.Mey. ex Sond.) Moffett*, comb. nov.

Rhus populifolia E.Mey. ex Sond. in Flora capensis 1: 508 (1860). Type: Northern Cape, mouth of the Gariep [Orange] River, *Drège s.n.* [TCD!, lecto., designated by Moffett: 105 (1993)].

Namibia, South Africa.

Searsia problematodes *(Merxm. & Rössl.) Moffett*, comb. nov.

Rhus problematodes Merxm. & Rössl. in Mitteilungen der Botanischen Staatssamlung München 11: 66 (1973). Type: South West Africa [Namibia], near Aus, Plateau/Aar, *Wiss 3001* (M, holo.!).

Namibia.

Searsia pterota *(Presl) Moffett*, comb. nov.

Rhus pterota Presl in Botanische Bemerkungen: 44 (1884). Type: Eastern Cape, *Ecklon & Zeyher 1116* (PRC, holo.–photo.!).

South Africa.

Searsia puccionii *(Chiov.) Moffett*, comb. nov.

Rhus puccionii Chiov. in Flora Somala 1: 132 (1929). Type: Somalia, coast of Migiurtini, near mouth of Nogal River, *Puccioni & Stefanini 849* (FT–photo.!, lecto, here designated).

Somalia.

Searsia pygmaea *(Moffett) Moffett*, comb. nov.

Rhus pygmaea Moffett in Botanical Journal of the Linnean Society 130: 39 (1999). Type: Mpumalanga, Barberton, near Agnes Mine, *Moffett 4905* (PRE, holo.!).

South Africa.

Searsia pyroides *(Burch.) Moffett* var. **dinteri** *(Engl.) Moffett*, comb. nov.

Rhus pyroides (Burch.) Moffett var. *dinteri* (Engl.) Moffett in Flora of southern Africa 19,3: 43 (1993). *R. dinteri* Engl.: 211 (1921). Type: South West Africa [Namibia], Schaaprivier, *Dinter 1898* [SAM!, lecto., designated by Moffett: 43 (1993)].

Namibia.

Searsia pyroides *(Burch.) Moffett* var. **gracilis** *(Engl.) Moffett*, comb. nov.

Rhus villosa L.f. var. *gracilis* Engl. in Monographiae phanerogamarum 4: 425 (1883). Type: Transvaal [Gauteng], Pretoria, *Rehmann 4742* [Z!, lecto., designated by Moffett: 45 (1993)].

Lesotho, South Africa, Swaziland.

Searsia pyroides *(Burch.) Moffett* var. **integrifolia** *(Engl.) Moffett*, comb. nov.

Rhus tridentata Engl. var. *integrifolia* Engl. in Monographiae phanerogamarum 4: 426 (1883).Type: Natal [KwaZulu-Natal], Inanda, *Rehmann s.n.* [Z!, lecto., designated by Moffett: 45 (1993)].

South Africa, Swaziland.

Searsia pyroides *(Burch.) Moffett*, comb. nov., var. **pyroides****

Rhus pyroides Burch. var. *pyroides*, Travels in the interior of southern Africa 1: 344 (1822). Type: Northern Cape, Asbestos Mtns, *Burchell 1796* (K, holo.!).

Ethiopia, Kenya, Lesotho, South Africa, Swaziland, Tanzania, Uganda, Zambia, Zimbabwe.

** In Central and East Africa this taxom is known as *R. vulgaris* Meikle.

Searsia quartiniana *(A.Rich.) A.J.Mill.* in A.J. Mill. et al. in International Journal of Plant Sciences 162: 1403 (2001).

Rhus quartiniana A.Rich.: 141 (1847). Type: Ethiopia, Tigray, Shire, *Quartin-Dillon & Petit s.n.* (P, holo.!).

Angola, Democratic Republic of the Congo, Ethiopia, Kenya, Namibia, South Africa, Tanzania, Zambia, Zimbabwe.

Searsia refracta *(Eckl. & Zeyh.) Moffett*, comb. nov.

Rhus refracta Eckl. & Zeyh., Enumeratio plantarum africanae australis extratropicae 2: 145 (1836). Type: Eastern Cape, Uitenhage, Zwartkops River, *Ecklon & Zeyher 1103* [S!, lecto., designated by Moffett: 73 (1993)].

South Africa.

Searsia rehmanniana *(Engl.) Moffett* var. **glabrata** *(Sond.) Moffett*, comb. nov.

Rhus pyroides Burch. var. *glabrata* Sond. in Flora capensis 1: 511 (1860). Type: Natal [KwaZulu-Natal], Oomcomas [Mkomaas], *Drège 5580* [S!, lecto., here designated, replacing the *Drège 6800* in P lectotype chosen by Moffett: 49 (1993)]*.

South Africa, Swaziland, Zambia, Zimbabwe.

Searsia rehmanniana *(Engl.) Moffett*, comb. nov., var. **rehmanniana**

Rhus rehmanniana Engl. in Monographiae phanerogamarum 4: 422 (1883). Type: Transvaal [Limpopo], Houtbosch, *Rehmann 5560* [Z!, lecto., designated by Moffett: 49 (1993)].

Mozambique, South Africa, Swaziland.

Searsia retinorrhoea *(Steud. ex Oliv.) Moffett*, comb. nov.

Rhus retinorrhoea Steud. ex Oliv. in Flora of tropical Africa 1: 438 (1868). Type: Ethiopia, Tigray Region, Dscheladscheranne, *Schimper 111: 1627* (K, holo.!).

Ethiopia, Somalia, Sudan, Yemen.

Searsia rigida *(Mill.) F.A.Barkley* var. **dentata** *(Engl.) Moffett*, comb. nov.

Rhus zeyheri Sond. var. *dentata* Engl. in Monographiae phanerogamarum 4: 433 (1883). Type: Eastern Transvaal [Mpumalanga], Transvaal Drakensberg, Laingsnek, *Rehmann 6942* (Z, holo.!).

South Africa.

Searsia rigida *(Mill.) F.A.Barkley* var. **margaretae** (*Burtt Davy ex Moffett*) *Moffett*, comb. nov.

Rhus rigida (Mill.) Moffett var. *margaretae* Burtt Davy ex Moffett in Flora of southern Africa 19,3: 36 (1993). Type: Transvaal [Gauteng], Elsburg, *Schlechter 3539* (PRE, holo.!).

South Africa, Swaziland.

Searsia rigida *(Mill.) F.A.Barkley* var. **rigida** in Monographs of the Biological Society of Iraq 3: 54 (1965).

Rhus rigida Mill.: 14 (1768). Type: ex *Herb. Miller* (BM, holo.!).

South Africa, Swaziland.

Searsia rimosa *(Eckl. & Zeyh.) Moffett*, comb. nov.

Rhus rimosa Eckl. & Zeyh., Enumeratio plantarum africanae australis extratropicae 2: 150 (1836). Type: Western Cape, Clanwilliam, Heerenlogement, *Ecklon & Zeyher 1124* [SAM sheet 2557!, lecto., designated by Moffett: 91 (1993)].

South Africa.

*Although both Drège specimens are the same taxon, a referee pointed out that 5580 is preferable as it has been annotated as *β glabrata* by Sonder.

Searsia rogersii *(Schönland) Moffett*, comb. nov.

Rhus rogersii Schönland in Bothalia 3: 42 (1930). Type: Eastern Transvaal, [Mpumalanga], Barberton, *Rogers 18270* [GRA!, lecto., designated by Moffett: 35 (1993)].

South Africa, Swaziland.

Searsia rosmarinifolia *(Vahl) F.A.Barkley* in Monographs of the Biological Society of Iraq 3: 53 (1965).

Rhus rosmarinifolia Vahl: 50 (1794). Type: Locality unknown, ex Herb. Hoffman-Bang e coll. Vahl, *Bulow s.n.* [C!, lecto., designated by Moffett: 99 (1993)].

South Africa.

Searsia rudatisii *(Engl.) Moffett*, comb. nov.

Rhus rudatisii Engl., Die Pflanzenwelt Afrikas 3,2: 217 (1921). Type: Natal [KwaZulu-Natal], Alexandra County, Friedenau, Mgai Flats, *Rudatis 698* [K!, lecto., designated by Moffett: 109 (1993)].

South Africa.

Searsia ruspolii *(Engl.) Moffett*, comb. nov.

Rhus ruspolii Engl. in Annuario Regius Istituto Botanico di Roma 7: 18 (1897–1898). Type: Ethiopia, Biddume, *Ruspoli & Riva 1317* (FT, holo.).

Democratic Republic of the Congo, Ethiopia, Kenya, Uganda.

Searsia scytophylla *(Eckl. & Zeyh.) Moffett* var. **dentata** *(Moffett)* Moffett, comb. nov.

Rhus scytophylla Eckl. & Zeyh. var. *dentata* Moffett in Flora of southern Africa 19,1: 93. Type: Western Cape, Ceres District, Agterwitzenberg, Modderriviersloof, *Van Jaarsveld 1538* (NBG, holo.!).

South Africa.

Searsia scytophylla *(Eckl. & Zeyh.) Moffett*, comb. nov., var. **scytophylla**

Rhus scytophylla Eckl. & Zeyh., Enumeratio plantarum Africae australis extratropicae 2: 150 (1836). Type: Western Cape, between Sir Lowry's Pass and Palmiet River, Grietjiesgat, *Ecklon & Zeyher 1130* [S, sheet 1!, lecto., designated by Moffett: 93 (1993)].

South Africa.

Searsia sekhukhuniensis *(Moffett) Moffett*, comb. nov.

Rhus sekhukhuniensis Moffett in Flora of southern Africa 19,3: 77 (1993). Type: Eastern Transvaal [Mpumalanga], Lydenburg District, Steelpoort Park Pass, *Moffett 2000* (PRE, holo.!).

South Africa.

Searsia somalensis *(Engl.) Moffett*, comb. nov.

Rhus somalensis Engl. in Abhandling der Königlike Preussiche Akademie für Wissenschaft 2: 289 (1891–1892). Type: Somalia, near Meïd, Serrút Mtns, *Hildebrand 1542* (K!, lecto., here designated).

Ethiopia, Somalia.

Searsia squalida *(Meikle) Moffett*, comb. nov.

Rhus squalida Meikle in Boletim Socicdade Broteriana, sèr. 2, 26: 283 (1952). Type: Angola, Calumba, *Welwitsch 4421* (BM, holo.!).

Angola, Zambia.

Searsia stenophylla *(Eckl. & Zeyh.) Moffett*, comb. nov.

Rhus stenophylla Eckl. & Zeyh., Enumeratio plantarum Africae australis extratropicae 2: 144 (1836). Type: Western Cape, Table Mountain and Hottentotshollandberge, *Ecklon & Zeyher 1094* [S!, lecto., designated by Moffett: 99 (1993)].

South Africa.

Searsia tenuinervis *(Engl.) Moffett*, comb. nov.

Rhus tenuinervis Engl. in Monographieae phanerogamarum 4: 423 (1883). Type: Angola, between Benguela and R. Catumbela, *Welwitsch 4418* [G-DC (Mon. Phan.), holo.!].

Angola, Botswana, Democratic Republic of the Congo, Ethiopia, Kenya, Malawi, Moçambique, Namibia, South Africa, Sudan, Tanzania, Zambia, Zimbabwe.

Searsia tenuipes *(R.Fern. & A.Fern.) Moffett*, comb. nov.

Rhus tenuipes R.Fern. & A.Fern. in Boletim Sociedade Broteriana, sèr. 2, 38: 191 (1965b). Type: Zimbabwe, Great Dyke, Mhlaba Hills, Charter, *Wild 5667* (SRGH, holo.!).

Mozambique, Zimbabwe.

Searsia thyrsiflora *(Balf.f.) Moffett*, comb. nov.

Rhus thyrsiflora Balf.f. in Proceedings of the Royal Society, Edinburgh 11: 507 (1882). Type: Socotra, *Balfour369* (BM!, lecto., here designated).

Socotra.

Searsia tomentosa *(L.) F.A.Barkley* in Flora of Texas 3: 104 (1943).

Rhus tomentosa L.: 266 (1753). Type: Cape of Good Hope, *Herb. LINN 378.20* [LINN, lecto.!, Wijnands: 42 (1983)].

South Africa, Zimbabwe.

Searsia transvaalensis *(Engl.) Moffett*, comb. nov.

Rhus transvaalensis Engl. in Monographiae phanerogamarum 4: 440 (1883). Type: Northern Transvaal [Limpopo], Houtbosch, *Rehmann 5559* [Z!, lecto., designated by Moffett: 29 (1993)].

South Africa, Swaziland.

Searsia tridactyla *(Burch.) Moffett,* comb. nov.

Rhus tridactyla Burch., Travels in the interior of southern Africa 1: 340 (1822). Type: Northern Cape, Asbestos Mtns, *Burchell 1667* (K, holo.!).

South Africa.

Searsia tripartita *(Ucria) Moffett*, comb. nov.

Rhamnus tripartitus Ucria in Nuovo racc. opusculum autore catalogus plantarum Siciliae 6: 249 (1793), Sicily. [Icono., here designated: left hand figure of plate *Rhamnus polytriphyllus*, p. 21 of reprint by Carta (1959) of Plantae ad Linneanum opus addendae—Bernadino da Ucria].

Algeria, Egypt, Israel, Jordan, Libya, Morocco, Palestine, Niger, Sicily, Sudan, Syria, Tunisia, Western Sahara.

Searsia tumulicola *(S.Moore) Moffett* var. **meeuseana** *(R.Fern. & A.Fern.) Moffett*, comb. nov., forma **meeuseana**

Rhus synstylica R.Fern. & A.Fern. var. *meeuseana* R.Fern. & A.Fern. forma *meeuseana* in Boletim Sociedade Broteriana, sèr. 2, 39: 251 (1965c). Type: Northern Transvaal [Limpopo], Venda, Lake Funduzi, *Meeuse 9409* (PRE, holo.!).

South Africa.

Searsia tumulicola *(S.Moore) Moffett* var. **meeuseana** *(R.Fern. & A.Fern.) Moffett* forma **pumila** *(Moffett) Moffett*, comb. nov.

Rhus tumulicola (S.Moore) Moffett var. *meeuseana* (R.Fern. & A.Fern.) Moffett forma *pumila* Moffett in Flora of southern Africa 19,3: 25 (1993). Type: Eastern Transvaal [Mpumalanga], Carolina, *Galpin 12493* (PRE, holo.!).

South Africa.

Searsia tumulicola *(S.Moore) Moffett*, comb. nov., var. **tumulicola**

Rhus tumulicola S.Moore in Journal of Botany 59: 227 (1921). Type: Northern Transvaal [Limpopo], The Downs, *Rogers 22033* (BM, holo.!).

South Africa, Zimbabwe.

Searsia undulata *(Jacq.) T.S.Yi, A.J.Mill. & J.Wen* in Molecular Phylogenetics and Evolution 33: 861 (2004).

Rhus undulata Jacq.: 52 (1798). Type: ex Hort. Schönbrunn, *Jacquin 379* [W!, lecto., designated by R.Fern.: 133 (1967)].

South Africa.

Searsia volkii *(Süsseng.) Moffett*, comb. nov.

Rhus volkii Süsseng. in Mitteilungen der Botanischen Staatssamlung München 1,8: 343 (1953). Type: South Africa [Namibia], Great Namaland, slopes of Tsaris Mtns, *Volk 752* (M, holo.!).

Namibia.

Searsia wellmanii *(Engl.) Moffett*, comb. nov.

Rhus wellmanii Engl., Die Pflanzenwelt Afrikas 3,2: 213 (1921). Type: Angola, Benguella District, De Moco, *Gossweiler 12357* (LISC!, neo., designated by R.Fern.: 356 (1966)].

Angola.

Searsia wildii *(R.Fern. & A.Fern.) Moffett*, comb. nov.

Rhus wildii R.Fern. & A.Fern. in Boletim Sociedade Broteriana, sèr. 2, 38: 192 (1965b). Type: Zimbabwe, Sipolilo, Mpingi Pass, *Wild 5776* (SRGH, holo.!).

Zimbabwe.

Searsia wilmsii *(Diels) Moffett*, comb. nov.

Rhus wilmsii Diels in Botanische Jahrbücher 24: 501 (1898). Type: Eastern Transvaal [Mpumalanga], Lydenburg District, *Wilms 249* [AMD!, lecto., designated by Moffett: 111 (1993)].

South Africa.

Searsia zeyheri *(Sond.) Moffett*, comb. nov.

Rhus zeyheri Sond. in Flora capensis 1: 514 (1860). Type: Transvaal [Gauteng], among shrubs at Magalisberg, *Zeyher 345* (S, holo.!).

South Africa.

ACKNOWLEDGEMENTS

I am grateful to the following persons who have assisted me in completing this paper: Laura Settesoldi of the Erbario Tropicale, University of Florence and Wang Yuhua of Kunming Institute of Botany, China for help in tracing obscure publications and for providing me with images of important specimens; Raul Puente of the Desert Botanic Garden, Phoenix, Arizona for sending me images of the voucher specimens used in the recent phylogenetic studies; Robert Archer and Hugh Glen of SANBI, Ted Oliver, formerly SANBI, Ashley Nicholas (when S.A. Liaison Officer at Kew), Peter Linder of the Institute of Systematic Botany, University of Zurich and John McNeill of the Royal Botanic Garden, Edinburgh, who all gave nomenclatural advice and three referees whose recommendations improved the paper. I am also grateful to the Department of Plant Sciences (Main & Qwaqwa Campus) of the University of the Free State, who provided logistical support.

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Bothalia 37,2: 177–182 (2007)

New species and notes on *Hesperantha* (Iridaceae) in southern Africa

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Keywords: *Hesperantha* Ker Gawl., Iridaceae, southern Africa, taxonomy

ABSTRACT

Field studies of the sub-Saharan African and largely southern African *Hesperantha* conducted since 2003 have resulted in the discovery of three new species in this genus, bringing the total to 82. *Hesperantha* **longistyla** J.C.Manning & Goldblatt, known from one collection from the mountains of SW Namibia, is a dwarf plant with moderately long-tubed, purple flowers and unusually long style branches, possibly allied to the Kamiesberg species, *H. latifolia*. A second species, *H.* **helmei** Goldblatt & J.C.Manning, also known from a single collection from the interior mountains of Eastern Cape near Graaff-Reinet, has terete leaves and small flowers with tepals ± 8 × 2.5 mm, about as long as the perianth tube. It is apparently most closely allied to the Roggeveld species, *H. ciliolata*. A third novelty, *H.* **lithicola** J.C.Manning & Goldblatt, restricted to the Swartruggens range in the eastern Cold Bokkeveld, has bell-shaped corms with toothed margins, leaves 1–2 mm wide, and white flowers with a tube 10–12 mm long, and appears most closely allied to the widespread *H. falcata*. A new collection of *H. karooica* from northeast of the Hantamsberg represents a small but significant range extension for this local endemic previously known from just two collections near Calvinia, south of these mountains. The flower size, especially dimensions of the tepals, confirms its status as a separate species allied to *H. vaginata*. Lastly, new collections of the relatively uncommon, yellow-flowered variant of *H. acuta* show that this plant, confined to the eastern portion of the range of the species, differs consistently from the white-flowered form in several floral features, and it is raised to subspecies rank as *H. acuta* subsp. *tugwelliae*.

INTRODUCTION

Hesperantha Ker Gawl. (Iridaceae: Crocoideae) is distributed across sub-Saharan Africa but is most diverse and species-rich in southern Africa. The genus has two centres of diversity here, the winter rainfall west (Goldblatt 1984), and the coast and adjacent mountains of the eastern, summer rainfall half of the subcontinent (Hilliard & Burtt 1986). In the most recent revision of the genus, 79 species were recognized (Goldblatt 2003). Although *Hesperantha* is now well understood taxonomically, three collections made since the publication of this revision represent novelties, all from areas of southern Africa that are poorly collected. We describe them here. In addition, a new collection and important range extension of the poorly known *H. karooica* Goldblatt confirm that flower size, especially dimensions of the tepals, consistently differs from that in the closely allied *H. vaginata* (Sweet) Goldblatt, removing doubts about its status as merely a depauperate form of the latter. In *H. acuta* new collections have provided convincing evidence that the eastern, yellow-flowered populations of the species consistently have larger flowers that differ in several additional features from the western, white-flowered populations. The yellow-flowered populations clearly constitute a separate race of the species, which we recognize as *H. acuta* subsp. *tugwelliae*. The total number of species in *Hesperantha* is thus increased to 82: 43 of these occur in the southern African winter rainfall zone; 39 in the southern African summer rainfall zone south of the Limpopo; and four in tropical Africa.

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MS. received: 2007-01-09.

TAXONOMY

Hesperantha longistyla *J.C.Manning & Goldblatt*, sp. nov.

Plantae ± 30 mm altae, cormo campanulato ± 10 mm diam. margine spinis radiatis armato, caule ad 8 mm longo, foliis 3 falcatis 30–50 × 2.5–3.0 mm, spica 1- vel 2-flora, bracteis viridibus 7–10 mm longis, floribus manifeste purpureis ad faucem tubi flavis, tubo perianthii 20–25 mm longo, tepalis subaequalibus anguste ovatis patentibus, staminibus adscendentibus, antheris ± 5 mm longis, ramis styli ± 10 mm longis laxe patentibus.

TYPE.—Namibia, 2716 (Witputz): south of Sebrafontein, 1 400 m, (–DD), 28 August 2003, *P. Bruyns 9484A* (NBG, holo.).

Plants ± 30 mm high; corm bell-shaped with flat base, ± 10 mm diam. at base, margin with radiating spines. *Stem* reaching up to 8 mm above ground, unbranched. *Leaves* 3, falcate, 30–50 × 2.5–3.0 mm; cataphylls membranous. *Spike* 1- or 2-flowered; bracts green, 7–10 mm long, outer about as long as inner or slightly longer, inner forked at apex. *Flowers* evidently purple, yellow in mouth of tube; perianth tube 20–25 mm long, slender, widening near apex; tepals subequal, narrowly ovate, ± 10 × 6 mm, outer slightly wider than inner, spreading horizontally. *Stamens* symmetrically disposed, slightly spreading; filaments ± 4 mm long, exserted ± 3 mm from tube; anthers ± 5 mm long. *Ovary* ovoid, ± 1.5 mm long; style dividing at mouth of perianth tube, branches ± 10 mm long, spreading laxly. *Capsules* and *seeds* unknown. *Flowering time:* mid-August to early September. Figure 1A.

Distribution and ecology: found in rock crevices at higher elevations in the mountains of southwestern

FIGURE 1.—A, *Hesperantha longistyla, Bruyns 9484A*; B, *H. helmei, Helme 3144*. Scale bars: 10 mm. Artist: J.C. Manning.

Namibia near Rosh Pinah, in the winter rainfall part of that country (Figure 2). Plants were growing among dolomite rocks and in crevices on the summit of a high ridge, where they would have benefited from any additional moisture that condensed from sea fog. It is likely that the species occurs elsewhere in suitable places in this rugged, largely inaccessible, and botanically poorly explored region. Known only from the type collection, made by Cape Town succulent specialist Peter Bruyns in 2003, *Hesperantha longistyla* is a surprising discovery, representing the only species of the genus known from Namibia.

Diagnosis and relationships: distinctive in its short stature, falcate leaves, relatively long perianth tube, 20–25 mm long, and disproportionately long style branches, *Hesperantha longistyla* has the bell-shaped corm with a flat base that characterizes a handful of other species in the genus from the southern African winter rainfall zone to the south, including white-flowered *H. falcata* (L.f.) Ker Gawl. as well as the two purple-flowered species, *H. latifolia* (Klatt) M.P.de Vos and *H. pauciflora* (Baker) G.J.Lewis. The last two species occur in Namaqualand, the former restricted to the Kamiesberg and the latter reaching its northern limit there, well to the south of

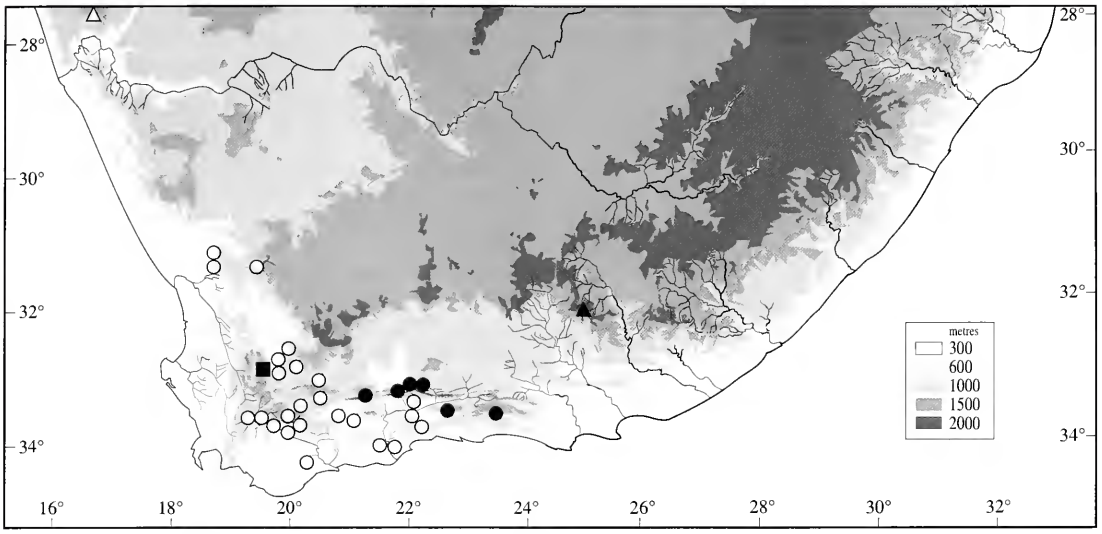

FIGURE 2.—Known distribution of *Hesperantha longistyla,* △*; H. helmei,* ▲; *H. lithicola,* ■; *H. acuta* subsp. *acuta,* ○; and *H. acuta* subsp. *tugwelliae,* ●.

Namibia. Nevertheless, the proximity of their ranges, and their similar flower colour suggest that *H. longistyla* is allied to these two species. *H. longistyla* is most similar to the long-tubed *H. latifolia* but differs in its smaller flowers, with tepals ± 10 mm long, and in the marked difference in the relative proportions of stamens and style. The filaments in *H. longistyla* are relatively short, 3–4 mm long and the style branches project ± 3 mm beyond the tips of the anthers, thus appearing unusually long. The flowers of *H. latifolia*, in contrast, are generally much larger, with tepals 15–23 mm long, the filaments (4–)7–10 mm long, and the style branches do not extend much beyond the tips of the anthers.

Hesperantha helmei *Goldblatt & J.C.Manning*, sp. nov.

Plantae 180–250 mm altae, cormo globoso asymmetrico ± 9 mm diam., caule eramoso in quarta superiore folium squamiformem gerente, foliis 3, inferioribus dua teretibus costatis, superiore vaginanti, spica 1- vel 2-flora, bracteis viridibus, ± 9 mm longis, floribus pallide malvinis, tubo perianthii 6–8 mm longo, tepalis subequalibus anguste ovatis ± 8 × 2.5 mm patentibus, filamentis ex tubo ± 2 mm exsertis, antheris ± 4 mm longis, ramis styli ± 3.5 mm longis.

TYPE.—South Africa, Eastern Cape, 3224 (Graaff-Reinet): ± 50 km E of Graaff-Reinet, upper northern slopes of Nardouwsberg, 1 km N of main peak, Annex Stijlfontein 250, 2300' [700 m], (–BB), 19 November 2004, *N.A. Helme 3144* (NBG, holo.).

Plants 180–250 mm high; corm globose, ± 9 mm diam., asymmetric, with concentric tunics. *Stem* slender, unbranched, bearing short, scale-like leaf in upper fourth. *Leaves* 3, lower 2 terete, conspicuously grooved, blades 8–15 × 1.2 mm, uppermost leaf sheathing lower half to two thirds of stem; cataphylls membranous. *Spike* 1- or 2-flowered; bracts green, ± 9 mm long, inner about as long as outer and forked at apex. *Flowers* pale mauve, darker at mouth of tube, outer tepals with broad purple streak on reverse; perianth tube 6–8 mm long, slender, widening near apex; tepals subequal, narrowly ovate, ± 8.0 × 2.5 mm, outer slightly larger than inner, spreading slightly above horizontal. *Stamens* symmetrically disposed, slightly spreading; filaments exserted ± 2 mm from tube; anthers ± 4 mm long. *Ovary* ovoid, ± 2 mm long; style dividing at mouth of perianth tube, branches ± 3.5 mm long, ascending, ultimately reaching to about middle of anthers. *Capsules* and *seeds* unknown. *Flowering time:* November and probably December. Figure 1B.

Distribution and ecology: apparently restricted to the southern edge of the interior escarpment, where it is known from a single collection made at high elevations in rocky grassland in the Sneeuberge, east of Graaff-Reinet (Figure 2). The plants were found in open areas in *Merxmuellera* grassland among dolerite boulders. These grasslands burn regularly every few years during the dry season and are regularly covered with snow in winter (N.A. Helme pers. comm.) The tips of the long, basal leaves in all the specimens have been burned or frosted off, indicating that the species begins leafing early in the growing season when the danger of fire or frost is not yet over.

Diagnosis and relationships: *Hesperantha helmei* is named for its discoverer, the Cape Town ecologist and energetic and wide-ranging plant collector, N.A. Helme. The species is distinctive in its relatively small, pale mauve flower with a perianth tube 6–8 mm long, narrow tepals ± 8.0 × 2.5 mm, and terete, finely ribbed leaves. Another unusual attribute of the species is the small, sheathing, scale-like leaf in the upper part of the stem. This distinctive feature is characteristic of a small group of species allied to *H. pilosa* (L.f.) Ker Gawl., all native to the winter rainfall zone of southern Africa. Among these species, *H. pilosa* is largely a species of the Cape floristic region, whereas *H. ciliolata* Goldblatt, *H. teretifolia* Goldblatt and the hairy-leaved *H. pseudopilosa*

Goldblatt are centred on the Roggeveld Escarpment of the Western Karoo (Goldblatt 1987). Among the species in this group, *H. helmei* is probably most closely related to *H. ciliolata* and *H. teretifolia*, which also have terete, prominently ridged leaves, the grooves lined with fine ciliate hairs that are absent in *H. helmei*. The flowers of *H. ciliolata* and *H. teretifolia* are slightly larger than those of *H. helmei,* with a perianth tube ± 8 mm long and tepals ± 10 mm long. *Hesperantha teretifolia* in particular is broadly similar to *H. helmei* in general appearance, but has minutely ciliolate leaf ribs, a small, scale-like leaf, 2–4 mm long, and larger anthers, ± 8 mm long. *H. helmei*, in contrast, has glabrous leaves, a larger scale-like leaf, 8–10 mm long, and smaller anthers, ± 4 mm long.

While the presence of an endemic species of *Hesperantha* in the Sneeuberge is surprising, it is not without precedent in the Iridaceae. A handful of species of the family occur there, including taxa from both the winter rainfall zone to the west and the summer rainfall zone to the east. Those from the winter rainfall zone include *Moraea ciliata, M. crispa* and *M. ungnicnlata.* The Iridaceae from the summer rainfall zone include one *Dierama* species, *Romulea macowanii*, three species of *Syringodea*, including the near endemic *S. pulchella*, and a distinctive short, broad-leaved form of *Babiana bainesii*. This mix of summer and winter rainfall species reflects the transitional position of these mountains, that have a grassland-dominated flora characteristic of the summer rainfall region at higher elevations but which receive predictable amounts of winter rainfall that permit the persistence of a handful of species from the winter rainfall zone to the west.

Hesperantha lithicola *J.C.Manning & Goldblatt*, sp. nov.

Plantae (40–)80–200(–290) mm altae, cormo campanulato, 7–10 mm diam., ad basem dentato, caule eramoso, foliis 4, inferioribus 2 suberectis vel falcatis (30–)50–100(–160) × 1–2 mm, spica 1–4-flora, floribus albis, tepalis exterioribus extra rubris, tubo perianthii 10–12 mm longis, tepals subaequalibus, 10–15 × 4.0–6.5 mm, filamentis 3–5 mm longis, antheris ± 6 mm longis, ramis styli 4.0–5.5 mm longis.

TYPE.—South Africa, Western Cape, 3219 (Wuppertal): Swartruggens, Farm Knolfontein, beween Katbakkies Pass and Skitterykloof, in loam and leaf litter on sandstone pavement, (–DC), 12 September 2006, *P. Goldblatt & J.C. Manning 12817A* (NBG, holo.; MO, PRE, iso.).

Plants (40–)80–200(–290) mm high; corm bell-shaped with flat base, 7–10 mm diam., breaking into segments below, margins fringed and often with radiating spines. *Stem* unbranched or rarely with one branch from near base. *Leaves* 4, lower 2 basal, suberect or falcate, often undulate or loosely coiled, midrib prominently raised and margins squared and minutely scabrid along both edges, blades (30–)50–100(–160) × 1–2 mm, uppermost leaf entirely sheathing; cataphylls membranous. *Spike* 1–4-flowered; bracts green, flushed reddish and becoming dry apically, 11–20 mm long, inner about as long as outer and forked at apex. *Flowers* white, outer tepals red outside, opening in evening and producing rosy citrus fragrance; perianth tube 10–12 mm long, not or slightly exserted beyond bracts, slender, widening near apex; tepals subequal, elliptic, 10–15 × 4.0–6.5 mm, outer slightly larger than inner, spreading horizontally when fully open. *Stamens* symmetrically disposed, slightly spreading; filaments 3–5 mm, exserted 2–3 mm from tube; anthers horizontal, pale yellow, ± 6 mm long. *Ovary* ovoid, ± 3 mm long; style dividing at mouth of perianth tube, branches 4.0–5.5 mm long. *Capsules* ellipsoid, 9–10 × 4 mm. *Seeds* subglobose with flattened chalaza and persistent funicle, golden brown, 1.0–1.5 mm diam., rugose, testa cells domed. *Flowering time:* September. Figure 3.

Distribution and ecology: known from sandstone rock pavement in the Swartruggens Mountains in the eastern Cold Bokkeveld, where the plants grow in rock crevices or shallow humus, often in the shelter of small shrubs (Figure 2).

Diagnosis and relationships: *Hesperantha lithicola* is distinctive in its symmetrical, bell-shaped corm and narrow, often twisted or coiled leaves. It is probably most closely allied to *H. falcata*, which it resembles in general appearance, but from which it differs in its consistently narrower leaves, 1–2 mm wide (vs. 4–8 mm in *H. falcata*), and longer perianth tube, 10–12 mm vs. 4–9 mm. The two species differ also in their habitats. *Hesperantha lithicola* is restricted to shallow soils on sandstone rock pavement, whereas *H. falcata* is a common and widespread species of seasonally moist, deeper clay or sandy soils. This ecological difference is very evident at the type locality, where *H. falcata* occurs on sandy flats not far from rocky outcrops to which *H. lithicola* is restricted.

Hesperantha lithicola is remarkably similar in general appearance to *H. acuta* (Licht. ex Roem. & Schult.) Ker Gawl. but this species has an asymmetrical corm with one side flattened and extended downward. Without corms, however, the two taxa are essentially indistinguishable, although *H. acuta* does not occur on the Cold Bokkeveld and is typically found on clay soils, rarely limestone or in pockets of loam on sandstone outcrops.

Other material examined

WESTERN CAPE.—3219 (Wuppertal): Katbakkies 139 Farm, exposed sandstone slope, (–DC), 20 September 1991, *C. Reid 1389* (NBG, PRE); Swartruggens, 60 km NE of Ceres, Knolfontein, 1 205 m, (–DC), 14 September 2005, *I. & C. Jardine 126* (NBG); Groenfontein, Zeekoegat, west of Riet River, 900 m, (–DC), 15 September 2001, *M.S. Stobie 7* (NBG).

TAXONOMIC NOTES

Hesperantha karooica Goldblatt

Known from just a handful of plants collected at two locations around Calvinia in Northern Cape, *Hesperantha karooica* is recognized among the species of the genus with large, asymmetric corms with overlapping tunics by its low stature, 30–50 mm high, and spikes of 1 or 2 yellow flowers with a tube ± 5 mm long and tepals ± 20 mm long (Goldblatt 1984, 2003). In general aspect

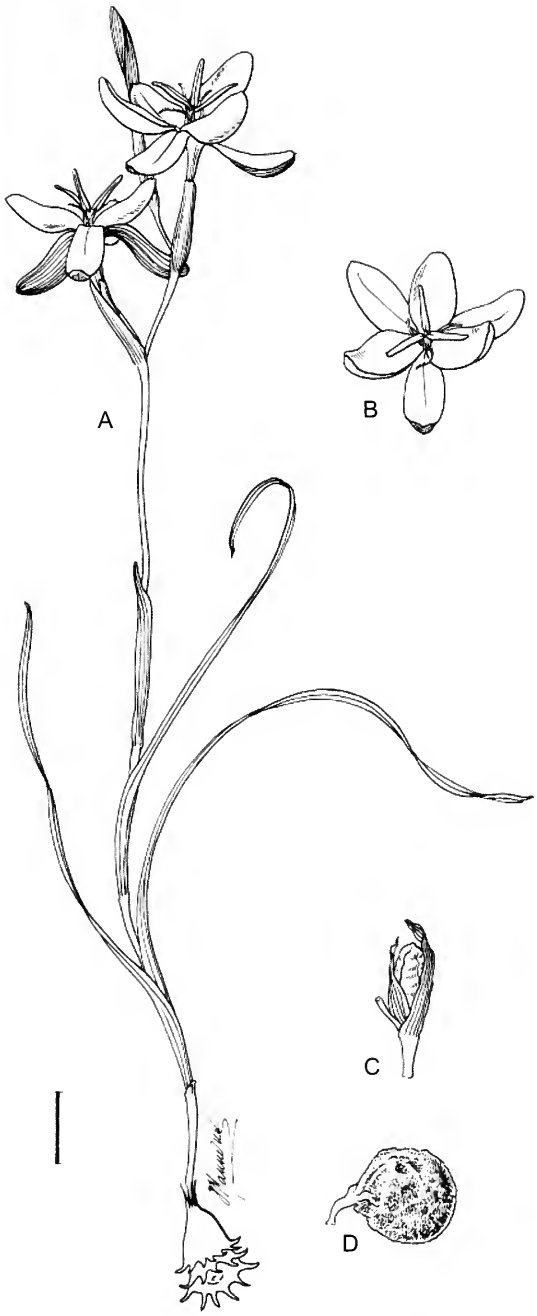

FIGURE 3.—*Hesperantha lithicola, Goldblatt & Manning 12817A*. A, whole plant; B, flower; C, capsule; D, seed. Scale bars: A–C, 10 mm; D, 1 mm. Artist: J.C. Manning.

the species is very like the more widespread Bokkeveld Plateau species, *H. vaginata* (Sweet) Goldblatt, which is normally taller, 120–180 mm high, and has spikes of (1)2–4 yellow flowers, usually marked with contrasting brown markings in the centre and on the tips of the outer tepals. Plain yellow-flowered plants are known from a few sites but both these and plants with marked tepals have a perianth tube 5–8 mm long and tepals 30–35 × 15–17 mm. Although the two species have been recognized in recent revisions of the genus (Goldblatt 1984, 2003), there has remained some doubt as to whether they are really distinct.

New collections of *Hesperantha vaginata* from near Loeriesfontein and of yellow-flowered plants that accord with *H. karooica* from well to the east of Calvinia, contribute to our understanding of the two taxa. The latter population, found some 50 km NNE of Calvinia on the road to Klipwerf in the area known as the Agter Hantam (*Goldblatt & Porter 12747*), consists of plants with bright yellow flowers, the outer tepals shaded brown outside, and ranging in height from 50 to 100 mm, with one plant found in the shade of a low shrub attaining a height of 160 mm. The flowers have a perianth tube 6–7 mm long, thus longer than until now reported for *H. karooica* and matching *H. vaginata*, but the tepals are ± 20 × 9–10 mm long and the anthers ± 10 mm long, thus ± as recorded for the two other collections of *H. karooica* (Goldblatt 1984).

The collection of *Hesperantha vaginata* from near Loeriesfontein (*Goldblatt & Porter 12775*), from the Farm Rietfontein, and which comprises a modest range extension (Goldblatt 1984), consists of plants 50–120 mm high, the smallest of these unusual for the species. All individuals have flowers with the brown markings on the inside of the tepals that are typical of the species and anthers that are ± 12 mm long and tepals 30 × ± 12 mm. Even the smallest plants have flowers typical of the species.

We conclude that plant height and perianth tube length are not factors that consistently distinguish the two species, but that anther length and tepal size always differ. The tepal size especially is substantially smaller in *Hesperantha karooica*. Both this species and *H. vaginata* typically grow on heavy red clay derived from dolerite, although populations of *H. vaginata* from the west of its range also occur on tillite-derived clay or a mix of clay and sand derived from Table Mountain Sandstone.

Range extensions

Hesperantha karooica

NORTHERN CAPE.—3119 (Calvinia): Agter Hantam, NNE of Calvinia on road between Moordenaarspoort and Klipwerf, stony dolerite clay flats, (–BB), 1 September 2006, *Goldblatt & Porter 12747* (MO, NBG, PRE).

Hesperantha vaginata

NORTHERN CAPE.—3119 (Calvinia): Farm Rietfontein, ± 48 km SE of Loeriesfontein, low dolerite clay hill, (–BC), 5 September 2006, *Goldblatt & Porter 12775* (MO, NBG, PRE).

Hesperantha acuta (Licht. ex Roem. & Schult.) Ker Gawl.

New and well-preserved collections of the yellow-flowered variant of *Hesperantha acuta* (Goldblatt 1984), until now believed to be rare, have provided us with additional information about the species. Typical white-flowered *H. acuta* is common in the western Karoo, and blooms prolifically in years of adequate rainfall. The flowers, including the anthers, are white, although the outer tepals are brown to red on the outside. Careful measurements of the stamens and styles show that the

TABLE 1.—Comparison of yellow- and white-flowered variants of *Hesperantha acuta*. Only well-pressed, fully open flowers were measured

Perianth colour	Yellow	White
Perianth tube length (mm)	12.5–15.0	8.5–12.0
Tepal length (mm)	12.5–16.0	(9.5–)11.0–16.0
Anther length (mm)	6–8	5.3–7.0
Filament exsertion (mm)	± 4	1.5–2.5
Style tip level	± middle of anthers	2 mm below to 1 mm above anther tips

filaments are exserted 1.5–2.5 mm from the tube and that the style branches reach from ± 2 mm below the anther tips to 1 mm above them. The tube itself is 8.5–12.0 mm long and the tepals 9.5–16.0 mm long (Table 1). Plants with flowers falling in the upper range of these dimensions are most common along the Cederberg but also occur over the entire range of the white-flowered variant of the species (Figure 2). Smaller-flowered plants occur mainly in the northwest of the range, along the foothills of the Bokkeveld and Matsikamma–Gifberg Mountains. Yellow-flowered plants, referred by R.C. Foster (1948) to *H. tugwelliae*, occur in the east of the range of *H. acuta*, in the northern foothills of the Swartberg Mountains, along the Kammanassie Mountains, and in the Long Kloof to the south in the vicinity of Joubertina (Figure 2). New collections made since 2002 (listed below) show that plants have a perianth tube 12.5–15.0 mm long and tepals 12.5–16.0 mm long, thus closely matching the white-flowered plants, but the filaments are exserted ± 4 mm and the anthers are 6–8 mm long, whereas the style branches reach only to about the middle of the anthers (Table 1).

These consistent differences in the dimensions of anthers and style provide proof, in addition to flower colour, that the eastern populations constitute a separate, larger-flowered race, and we believe it is useful to recognize the yellow-flowered populations as a separate taxon. Because of the small differences between the two, and complementary geographic ranges, we recommend subspecies rank for the taxon, and thus make the combination *H. acuta* subsp. *tugwelliae*.

Hesperantha acuta subsp. **tugwelliae** *(R.C.Foster) Goldblatt & J.C.Manning*, comb. et stat nov. *Hesperantha tugwelliae* R.C.Foster, Contributions from the Gray Herbarium 166: 26 (1948). Type: South Africa, [Western Cape], Prince Albert, *Tugwell s.n.* (*Nat.Bot.Gard.1151/29* in K, holo.!, BOL, MO, iso.!).

Selected specimens

WESTERN CAPE.—3321 (Ladismith): 30 miles beyond Seven Weeks Poort along Ladismith–Laingburg road, (–AC), 9 September 1971, *Thomas s.n* (*NBG93821*); Swartberg, between Matjesvlei and Gamkaspoort, (–BC), Oct. 1986, *Vlok s.n.* (MO); Swartberg Mtns, road to Gamkaskloof, (–BD), 9 September 2001, *Goldblatt & Porter 11859* (MO, NBG). 3322 (Oudtshoorn): Prince Albert, Farm Kleinsleutelfontein, (–AB), 1 August 1995, *Marincowitz sub Snijman 1492* (NBG); Kareedouw Pass between Klaarstroom and Prince Albert, (–AD), 10 September 2002, *Goldblatt & Porter 12191* (MO, NBG); Groot Doorn River, (–CD), August 1931, *Thorne s.n.* (*SAM51710*). 3323 (Willowmore): eastern slopes of Kammanassie Mtns, Farm Wildepaardefontein, (–CA), 18 August 1986, *Viviers & Vlok s.n.* (MO); Kammanassie Mtns, lower steep slopes above Buffelsdrif, (–DB), 8 August 1983, *Matthews 1128* (NBG).

EASTERN CAPE.—3323 (Willowmore): 8 km west of Joubertina, (–DD), 24 August 1981, *Snijman 450* (NBG); hill north of Joubertina, (–DD), August 1923, *Fourcade 2690* (BOL, K, NBG).

ACKNOWLEDGEMENTS

Support for this work by grants 7316-02 and 7799-05 from the National Geographic Society is gratefully acknowledged. We thank Peter Bruyns, Nicholas Helme, and Ivor and Cora Jardine for drawing our attention to the novelties described here. We also acknowledge our debt to Ingrid Nänni and Lendon Porter for their assistance and companionship in the field and to Roy Gereau for checking our Latin descriptions. Collecting permits were provided by the Nature Conservation authorities of Western Cape Province, South Africa.

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Bothalia 37,2: 183–187 (2007)

New species of *Drimia* (Hyacinthaceae: Urgineoideae) allied to *Drimia marginata* from Western and Northern Cape, South Africa

J.C. MANNING* and P. GOLDBLATT**

Keywords: *Drimia* Jacq., Hyacinthaceae, South Africa, taxonomy, Urgineoideae

ABSTRACT

Plants until now identified as *Drimia marginata* (Thunb.) Jessop on account of their leathery, oblong to elliptical leaves with thickened, cartilaginous margins and capitate inflorescences of campanulate flowers, are shown to comprise three sets of populations separable on leaf morphology, ecology and distribution. Typical *D. marginata* produces 1(2) oblong, apiculate leaves with retrorsely-scabridulous margins and occurs in fine-grained clay soils on the Hantam and Roggeveld Plateaus. Plants from Namaqualand and the Richtersveld, described here as *Drimia* **pulchromarginata** J.C.Manning & Goldblatt, occur in sandy or gravelly soils and produce 2–4, elliptical to suborbicular, apiculate leaves with an ornate, duplex margin: the dorsal surface bears a submarginal band of dense, velvety trichomes fringing the thickened, colliculate margin. A third series of populations from seasonally moist sandstones at higher altitude on the interior mountains of the West Coast produces 2 or 3(4) narrowly oblong, obtuse leaves with a simple, papillate or colliculate margin and are recognized as *D.* **ligulata** J.C.Manning & Goldblatt. A fourth taxon with a similar capitate inflorescence of campanulate flowers produces a solitary, subterete or subclavate leaf, elliptical in section. Recorded from scattered localities in the Northern and Western Cape, it is here described as *D.* **vermiformis** J.C.Manning & Goldblatt.

The genus *Drimia* Jacq. comprises ± 100 species of largely deciduous geophytes distinguished from other members of subfamily Urgineoideae, one of four subfamilies of the Hyacinthaceae, by their apomorphic, short-lived flowers with the tepals ± united at the base (Manning *et al.* 2004). Each flower lasts just several hours or up to a day, and the perianth is caducous and circumscissile, abscising at the base and withering as a cap on the developing capsule. The genus includes several smaller groups of obviously related species with spurred floral bracts, some of which were previously treated as separate genera, including *Rhadamanthus* Salisb., *Schizobasis* Baker and *Tenicroa* Raf. (Jessop 1977). Among those taxa traditionally retained in the poorly defined genus *Urginea* itself, is a small assemblage of species from the winter rainfall region of the Western and Northern Cape Provinces characterized by their capitate inflorescence of campanulate flowers with spreading tepals. Florally rather uniform, the species in the group are distinguished by their foliage: *D. barkerae* J.C.Manning & Goldblatt by a rosette of oblanceolate, ± ciliate leaves with simple margins; *D. marginata* (Thunb.) Jessop by two or three, oblong to elliptical leaves with heavily thickened margins; and *D. minor* (A.V.Duthie) Jessop by filiform or subterete leaves (Jessop 1977; Manning *et. al.* 2002; Manning & Goldblatt 2003). Another taxon in this group, with a solitary, subcylindrical or clavate leaf, has been referred to *D. virens* Schltr. (Goldblatt & Manning 2000; Manning *et al.* 2002).

It is now clear that three distinct species are included within the concept of *Drimia marginata* as currently circumscribed (Jessop 1977; Goldblatt & Manning 2000). These three entities are separable by differences in the number, shape, apex, and especially the marginal ornamentation of the leaves, as well as ecology and distribution. Typical *D. marginata* is characterized by oblong, apiculate leaves with thickened, minutely retrorsely scabridulous margins, and occurs in fine-grained clay soils on the Hantam and Roggeveld Plateaus. A second series of populations from seasonal sandstone rock flushes at moderate altitudes in the mountains of the southwestern Cape, described here as *D. ligulata* J.C.Manning & Goldblatt, produces narrowly oblong, truncate leaves with a papillate margin. A third group of populations, described here as *D. pulchromarginata* J.C.Manning & Goldblatt, occurs further north, in Namaqualand and the Richtersveld, in sandy or gravelly soils, and is characterized by its broader, elliptical to suborbicular leaves with a unique duplex margin comprising an outer rim of papillae, edged on the inner side by a dense, narrow, velvety band of minute trichomes.

Furthermore, examination of the syntypes of *Drimia virens, Schlechter 10127* and *Leipoldt s.n.*, reveals that the species falls within the current circumscription of *D. minor* (Duthie) Jessop, a species characterized by several, erect or spreading, linear or filiform leaves (Manning *et al.* 2002). In his review of the genus *Drimia*, Jessop (1977) treated *Urginea virens* as a synonym of *D. modesta* (Baker) Jessop, a species from the summer rainfall region with an elongate inflorescence but it is clearly misplaced here. *Drimia virens* is a combination based on *Urginea virens* Schltr. (1897) and as such is an earlier name for this species and we formally synonymize *D. minor* below.

The plants with a single, fleshy, subclavate leaf that were previously referred to *D. virens* by us (Goldblatt & Manning 2000; Manning *et al.* 2002) comprise a distinct species, which we describe here as *D. vermiformis* J.C.Manning & Goldblatt.

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MS. received: 2007-05-07.

Drimia vermiformis *J.C.Manning & Goldblatt*, sp. nov.

D. virens sensu Goldblatt & Manning (2000), non *D. virens* (Schltr.) J.C.Manning & Goldblatt.

Species *Drimiae minori* similis sed folio uno, 50–80 × 2–4 mm, suberecto vel expanso, carnoso subclavato, floribus campanulatis, pallide brunneis tepalis carinis atrobrunneis, tepalis biseriatis per ± 1 mm connatis.

TYPE.—Western Cape: 3218 (Clanwilliam), Clanwilliam Dam, picnic site along N7 near wall, (–BB), 3 August 1987 (fl. in cult. 11 October 1988), *P.L. Perry 3587* (NBG, holo.).

Deciduous, bulbous herb. *Bulb* solitary, subglobose, 15–20 mm diam.; outer tunics pale brown, thinly leathery; inner tunics tightly overlapping, white or flushed pink. *Leaf* dry and withered at flowering, 1(2), spreading or suberect, leathery, dark green; blade falcate or subclavate, subterete or ellipsoid in section, 50–80 × 2–4 mm, glabrous or minutely hispidulous. *Inflorescence* nodding in bud; scape erect or flexuose at base, (20–)50–120 mm long, glabrous; raceme corymbose-capitate, 2–5 mm long, densely 5–20-flowered; bracts elliptical, ± 2 mm long, lower with spur 1–2 mm long; pedicels spreading, 5–10 mm long at anthesis. *Flowers* campanulate, 1 or 2 open at a time, pale brownish with darker keels, opening in the late afternoon and fading in the evening, apparently unscented; tepals biseriate with blades of outer series overlapping inner, penicillate at apex, fused for ± 1 mm, erect below forming a cup ± 1.5 mm deep, spreading above; blades of outer tepals ovate, ± 5.0 × 2.0 mm, inner oblong, ± 4.5 × 1.8 mm, weakly canaliculate at top of cup. *Stamens* adnate to perianth for ± 0.5 mm; filaments erect, subterete and tapering, ± 2.5 mm long; anthers erect, dorsifixed, dehiscing by longitudinal slits, ± 1 mm long, yellow with yellow pollen. *Ovary* ellipsoid, ± 2 mm long, truncate, greenish yellow; style columnar, ± 1.5 mm long, white, apically truncate with trigonous, papillate stigma. *Capsules* subglobose, 5–6 × ± 5 mm, erect on suberect, slightly curved pedicels. *Seeds* compressed, elliptical or rectangular, 2–3 mm diam., glossy black, irregularly folded, testa finely reticulate. *Flowering time:* October and November. Figure 1.

Distribution and ecology: widely distributed through the arid parts of the southwestern Cape, from Bushmanland in Northern Cape southwards onto the Roggeveld and Nuweberg Escarpments and into Western Cape, extending westwards through the arid Doring River Basin into the lower Olifants River Valley around Clanwilliam, and into the Little Karoo as far east as Oudtshoorn (Figure 2). The species is certainly more common than records indicate. Plants occur on exposed, mostly shale flats and lower slopes in fine-grained clay or loam. Populations in the Little Karoo around Calitzdorp have been recorded from quartz patches.

Additional specimens examined

NORTHERN CAPE.—2919 (Pofadder): Pofadder, (–AB), 14 October 1954, *E. Esterhuysen 23640a* (BOL). 3120 (Williston): Roggeveld Escarpment, Middelpos, hill behind school, (–CC), 12 September 2001 (in bud), *D. Snijman & Van der Westhuysen 1853* (NBG).

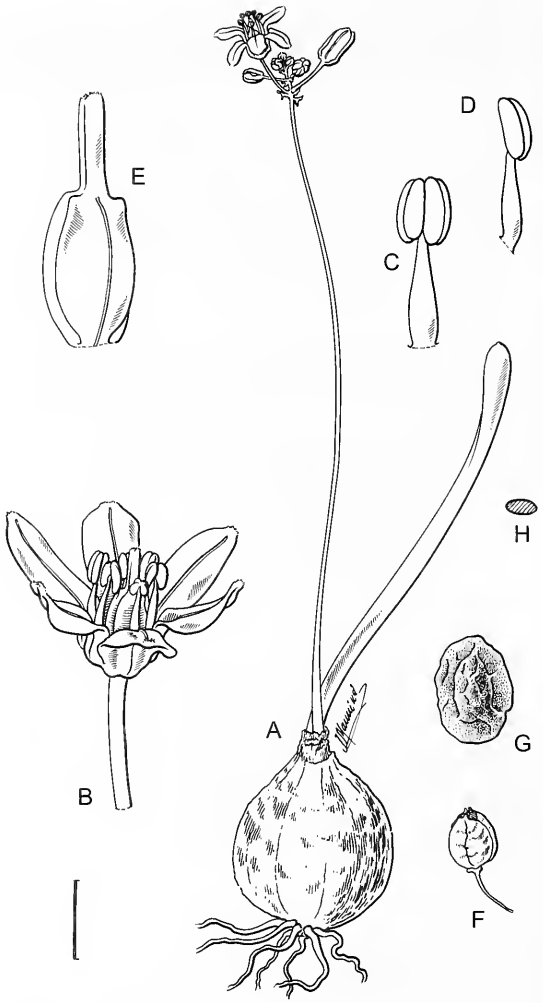

FIGURE 1.—*Drimia vermiformis*, *Manning 3092*. A, whole plant; B, flower. C, D, stamen: C, front view; D, side view. E, gynoecium; F, capsule; G, seed; H, c/s leaf. Scale bar: A, F, H, 10 mm; B, G, 2 mm; C–E, 1 mm. Artist: John Manning.

WESTERN CAPE.—3118 (Vanrhynsdorp): Trawal, steep slopes west of N7, (–DC), 31 August 2003 (in bud), *P.V. Bruyns 9523* (NBG); Trawal, right hand slope below N7 leading to Olifants River, (–DC), 15 April 2007, *J. Manning 3092* (NBG). 3218 (Clanwilliam): Zwart Vley, near upper waterfall east of Uitspankraal on Doring River, (–AB), 16 September 1992 (in cult.), *D. Snijman 1223* (NBG). 3222 (Beaufort West): Stolshoek, [Karoo National Park, west of Beaufort West], (–AD), 13 September 1989, *P. Bruyns 3977* (BOL). 3320 (Montagu): near Montagu, (–CC), September 1933, *M.R. Levyns 4600* (BOL); 13.5 km east of Bonnievale, (–CC), without date, *P.L. Perry s.n.* (NBG). 3321 (Ladismith): Farm Droogkraal, 30 km NW of Oudtshoorn, (–BD), 1 October 1980, *A. Bean s.n.* (NBG); road to Rooiberg Pass, SW of Radleigh, (–DA), *E.G.H. Oliver 3665* (NBG).

Drimia virens *(Schltr.) J.C.Manning & Goldblatt* in Strelitzia 9: 712 (2000), *Urginea virens* Schltr.: 433 (1897). Type: [Western Cape], Cold Bokkeveld, Tweefontein, 24 January 1897, *Schlechter 10127* (BOL, lecto.!, here designated; E!, GRA!, BM, K!, L, P, PRE!, S!, Z, isolecto.).

D. minor (Duthie) Jessop: 306 (1977). *Urginea minor* Duthie: 11 (1928), syn nov. Type: [Western Cape], Stellenbosch Flats, March 1924, *Duthie s.n. STE1546* (NBG, holo.!).

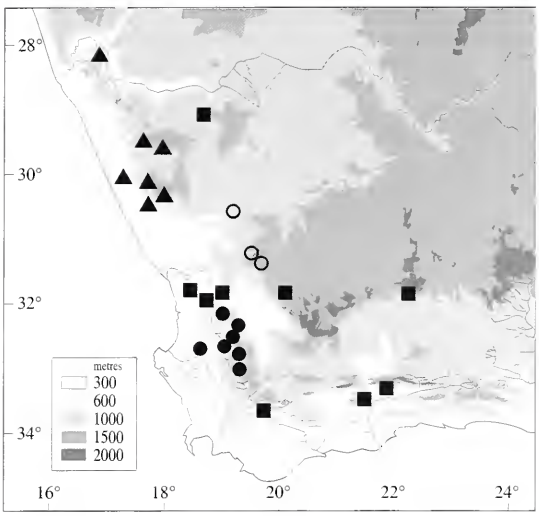

FIGURE 2.—Known distribution of *Drimia vermiformis*, ■; *D. ligulata*, ●; *D. marginata*, ○; *D. pulchromarginata*, ▲.

THE *DRIMIA MARGINATA* COMPLEX

Drimia marginata *(Thunb.) Jessop* in Journal of South African Botany 43: 295 (1977). *Anthericum marginatum* Thunb.: 63 (1794). *Idothea marginata* (Thunb.) Kunth.: 346 (1843). *Urginea marginata* (Thunb.) Baker: 218 (1873). Type: [Northern Cape], Hantam, without exact date, [November 1774], *Thunberg s.n.* (*UPS-8393*, holo.–microfiche!).

Deciduous, bulbous herb. *Bulb* solitary, subglobose, 15–30 mm diam.; outer tunics pale brown, thinly leathery; inner tunics tightly overlapping, white. *Leaf* dry and withered at flowering, 1(2), spreading or prostrate, leathery, dark green, base amplexicaul; blade oblong to oblanceolate, apiculate, 30–50(–60) × 9–15 mm, glabrous or minutely hispidulous, margin adaxially thickened, cartilaginous and densely and minutely retrorsely scabridulous, ± 0.5 mm wide. *Inflorescence* erect or flexuose at base; scape (100–)150–200 mm long, glabrous; raceme capitate, 2–10 mm long, densely 10–20-flowered; bracts elliptical, 2–3 mm long, lower spurred with spur 1–2 mm long; pedicels spreading, 5–10 mm long at anthesis. *Flowers* campanulate, 1 or 2 open at a time, pale brownish with darker keels; tepals biseriate with blades of outer series overlapping inner, penicillate at apex, fused for ± 1 mm, erect below and forming a cup ± 1.5 mm deep, spreading above, blades of outer tepals ovate, ± 5.0 × 2.0 mm, inner oblong, ± 4.5 × 1.8 mm. *Stamens* adnate to perianth for ± 0.5 mm; filaments erect, subterete and tapering, ± 2.5 mm long; anthers erect, dorsifixed, introrse, dehiscing by longitudinal slits, ± 1 mm long, yellow with yellow pollen. *Ovary* ovoid, ± 2 mm long, truncate, greenish yellow; style columnar, ± 1.5 mm long, white, apically truncate with trigonous, papillate stigma. *Capsules* and *seeds* unknown. *Flowering time:* October and November.

Distribution and ecology: apparently restricted to the Hantam Plateau in Northern Cape, between Loeriesfontein and Calvinia (Figure 2), on open clay flats in renosterveld vegetation.

Discussion: the first species in the complex to be described, *D. marginata* is still relatively poorly collected. It is distinguished by its oblong to oblanceolate, distinctly apiculate leaves with a thickened margin that is densely ornamented with minute, stiff, retrorse trichomes 0.2–0.2 mm long (Figure 3C, D). The blade may be glabrous or minutely hispidulous and typically just a single leaf is produced (rarely two).

The species appears to be restricted to fine-grained clay soils derived from shale or dolerite. No information is recorded on the time of anthesis, nor on floral fragrance.

Additional specimens examined

NORTHERN CAPE.—3019 (Loeriesfontein): 15 km from Loeriesfontein on road to Kliprand, (–CD), 13 September 2000 (in leaf), *P. Goldblatt, J. Manning & V. Savolainen 11525* (NBG). 3119 (Calvinia): Farm uitvlug NW of Calvinia, (–BC), 6 July 2000 (fl. in cult. 5 October 2000), *J. Manning 2270A* (NBG); Hantam Mtn, Akkerdam, (–BD), 22 July 1961 (fl. in cult. 14 November 1961), *W.F. Barker 9343* (NBG). 3120 (Williston): northern foot of Klein Tafelberg, (–CA), 22 October 1991, *P.V. Bruyns 4293* (BOL).

Drimia pulchromarginata *J.C.Manning & Goldblatt,* sp. nov.

Species *Drimiae marginatae* similis sed decidua vel sempervirens, tunicis bulbi interdum laxe dispositis, foliis 2–4, latioribus ellipticis ad suborbicularibus usitate 15–25 mm latis, marginibus incrassatis parte dorsali pernatis supra colliculosis infra dense scabridulis, parte ventrali simplicibus colliculosis.

TYPE.—Northern Cape: 3018 (Kamiesberg), Farm Draaiklip, (–AA), 31 October 1983 (fl. in cult.), *C.H. Stirton 9226* (NBG, holo.!).

Evergreen or deciduous, bulbous herb. *Bulb* solitary, subglobose, 20–30 mm diam.; outer tunics pale brown, thinly leathery; inner tunics sometimes loosely arranged, white. *Leaves* green or drying at flowering, (1)2–4, prostrate or erect, leathery, dark green, sometimes purple beneath, base flat; blade elliptical to broadly elliptical or suborbicular, acute, 25–60 × (13–)15–25 mm, glabrous or minutely hispidulous adaxially, margin thickened, cartilaginous, 0.5–1.0 mm thick, colliculate, with adaxial submarginal band ± 0.5 mm wide of dense, suberect or weakly retrorse trichomes ± 0.1 mm long. *Inflorescence* erect or flexuose at base; scape (60–)150–300 mm long, glabrous; raceme capitate, 2–5(–20) mm long, densely 10–30-flowered. *Flowers* as in *D. marginata*, usually opening in late afternoon and fragrant. *Capsules* and *seeds* unknown. *Flowering time*: October and November.

Distribution and ecology: endemic to the western parts of Northern Cape, from the Richtersveld and higher-lying parts of northern and central Namaqualand as far south as Garies, rarely near the coast (Figure 2). Plants typically occur on sandy or gravelly flats among granite outcrops, sometimes on quartz patches. Anthesis has been variously recorded as in the afternoon (*Hall 4172*) or morning (*Harrower 1521*) and the floral fragrance described as either unpleasant (*Stirton 9226*) or freesia-like (*Harrower 1521*).

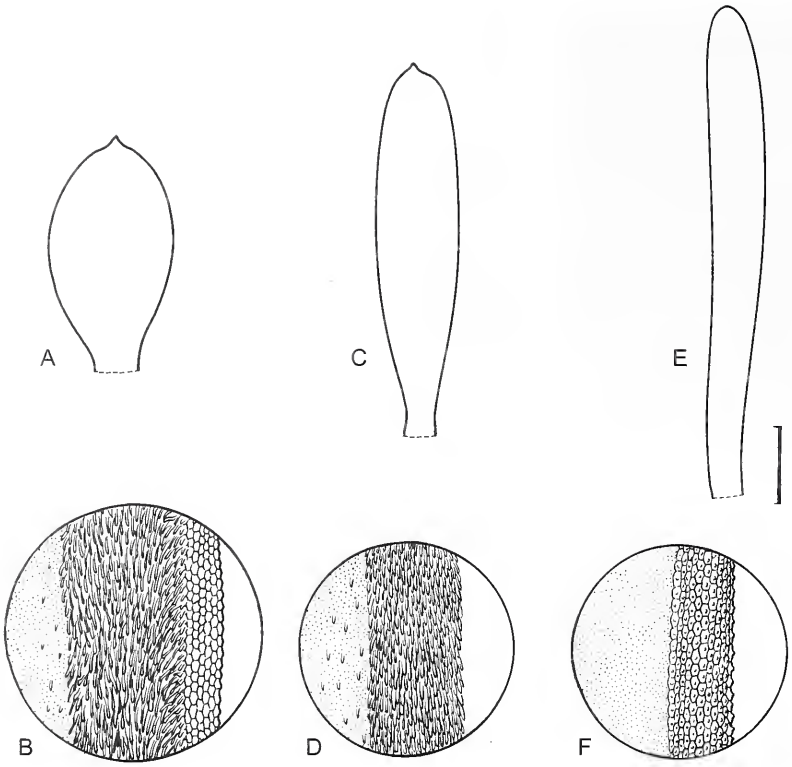

FIGURE 3.—Leaf shape and leaf margin in *Drimia marginata* complex. A, B, *Drimia pulchromarginata, Stirton 9226;* C, D, *D. marginata, Goldblatt, Manning & Savolainen 11525;* E, F, *D. ligulata, Esterhuysen 14487.* Scale bar: A, C, E, 10 mm; B, D, F, 0.5 mm. Artist: John Manning.

Discussion: the northernmost member of the *Drimia marginata* complex, *D. pulchromarginata* is distinguished by its elliptical to suborbicular, apiculate leaves, mostly 15–25 mm wide, with a highly ornamented, duplex margin comprising a narrow, colliculate rim edged internally with a broader band, ± 0.5 mm wide, of closely packed, suberect or weakly retrorse trichomes ± 0.1 mm long (Figure 3A, B). This uniquely complex margin is developed only on the adaxial surface, and the margin on the ventral surface is simple and colliculate, as found in *D. ligulata*. The leaves of *D. pulchromarginata* are also characteristically broader and more elliptical than in the other species in the complex. Typically 2–4 leaves are produced, and the plants remain evergreen if conditions permit.

The development of dense trichomes along the leaf margins in *Drimia marginata* and *D. pulchromarginata* is evidently a derived character and suggests that these two taxa are allopatric sister species.

Additional specimens examined

NORTHERN CAPE.—2817 (Vioolsdrif): Richtersveld, Chubiesics, (–AB), 15 October 2006 (fl. in cult.), *A. Harrower 1521* (NBG). 2917 (Springbok): Springbok, (–DB), January 1977, *B. Jeppe s.n. PRE57508* (PRE). 2918 (Gamoep): Vaalkoei, 1 000 m, (–CD), 10 July 1991 [fl. 4 November 1991], *P.V. Bruyns 4713* (PRE). 3017 (Hondeklipbaai): Riethuis, (–AB), 11 July 1989 [as 1898] [fl. 21 October 1991], *P. Bruyns 3879* (BOL); 6 km NNE Riethuis on road to Springbok, (–AB), without date, *J. Manning 1040* (NBG); Kamieskroon, (–BB), 9 November 1950, *W.F. Barker s.n. NBG1181/50* (NBG); Kharkams, (–BD), 18 October 1971, *H. Hall 4172* (NBG); Darter's Grave, 22 miles N of Garies, (–BD), August 1932, *J.Mathews s.n. NBG1891/31* (BOL); 4 May 1963 (fl. in cult. 18 November 1963), *L. Booysen 13* (NBG). Without precise locality or date: [Northern Cape], Namaqualand, 1924, *Giffen s.n. NBG1051/24* (BOL).

Drimia ligulata *J.C.Manning & Goldblatt*, sp. nov.

Species *Drimiae marginatae* similis sed foliis 2–3(–4), angustioribus oblongis usitate 6–10, raro ad 15 mm latis, expansis vel prostratis obtusis, marginibus simplicibus papillosis, papillis truncatis vel acutis, racemo corymboso-capitato, florescentia Decembri Januarique.

TYPE.—Western Cape: 3218 (Clanwilliam), Piketberg Mtns, Zebra Kop, (–DB), 23 May 1948 (fl. Dec–Jan 1948 and 1949), *E. Esterhuysen 14487* (BOL, holo.).

Deciduous, bulbous herb. *Bulb* solitary, subglobose, 15–30 mm diam.; outer tunics pale brown, thinly leathery; inner tunics tightly overlapping, white. *Leaves* dry and withered or emergent at flowering, 2 or 3(4), prostrate or spreading, leathery, dark green, base amplexicaul; blade oblong, obtuse, (20–)30–90 × (4–)6–10(–15) mm, glabrous, margin thickened, cartilaginous, 0.5 mm thick, papillate or colliculate. *Inflorescence* erect or flexuose at base; scape (60–)80–200 mm long, glabrous; raceme corymbose-capitate, 2–20 mm long, densely 5–20-flowered. *Flowers* as in *D. marginata*, usually fragrant. *Capsules* spreading or suberect on pedicels 5–18 mm long, ovoid to subglobose, 6–8 × 5–7 mm. *Seeds* elliptical to reniform, peripherally winged, 3–4(–6) × 1.8–2.5 mm long, glossy black, irregularly folded, testa finely reticulate. *Flowering time*: December and January, rarely as early as October at lower altitudes.

Distribution and ecology: recorded from most of the western mountain chains of the Cape Fold Belt of Western Cape, from the northern Cedarberg southwards through the Cold Bokkeveld Mountains and the Skurwe-

berg, and also on the higher parts of the Piketberg to the west (Figure 2). Plants grow in seasonally moist rock flushes or shallow rock basins on sandstone.

Discussion: the most commonly collected of the three species of the *Drimia marginata* complex, *D. ligulata* is distinguished by its generally narrower, oblong leaves, usually 6–10(rarely up to 15) mm wide, with an obtuse apex and a simple, papillate margin (Figure 3E, F). Typically two or three leaves are produced, rarely up to four. The leaf margin is thickened on both dorsal and ventral surfaces and the papillae may be blunt or acute. Other members of the complex have broader, oblong or elliptical leaves that are distinctly apiculate and have margins that are partially or entirely ciliolate.

Drimia ligulata is geographically and ecologically distinct from other members of the complex, being confined to seasonally moist sandstone substrates at moderately high altitudes, between 500–1 500 m, in the western mountains of the Cape Fold Belt. At these altitudes the species flowers later than *D. marginata* and *D. pulchromarginata*, typically in December and January, rather than October and November.

Additional specimens examined

WESTERN CAPE.—3218 (Clanwilliam): Piketberg, (–DC), December 1950, *E. Esterhuysen 14487* (BOL); Piketberg, S entrance to Kapteinskloof, (–DC), 22 October 1935, *N. Pillans 8092* (BOL). 3219 (Wuppertal): Cedarberg, between Pakhuis and Heuning Vlei, (–AA), 28 December 1941, *E. Esterhuysen 7426* (BOL); Cedarberg, Tafelberg, (–AC), 29 December 1947, *E. Esterhuysen 14337* (BOL); Cedarberg, Wolfberg, (–AC), 3 October 1952 (fl. December 1952), *E. Esterhuysen 20587* (BOL); Elands Kloof, (–CA), 29 September 1944 (leafing), *W.F. Barker 3072* (NBG), 9 September 1946 (leafing), *W.F. Barker 3822* (NBG), 24 September 1956 [fl. 18 November 1955], *T.P. Stokoe SAM68464* (SAM); W slopes of Cold Bokkeveld Mtns near Keerom, (–CC), 4 December 1950, *E. Esterhuysen 17922* (BOL). 3319 (Worcester): Kliphuis Vlakte on the Skurweberge, (–AA), 10 September 1989 (leafing), *D. Snijman 1236* (NBG); Schurweberg, between Bokkeveld Tafelberg and Bokkeveld Sneeuwberg, ± 5000' [1 500 m], (–AA), 11 October 1952 (fl. December 1962), *E. Esterhuysen 20662* (BOL); Hansiesberg, (–AB), 16 December 1944, *R.H. Compton 16689* (NBG); top of Gydo Pass, (–AB), 7 December 1940, *E. Esterhuysen 3952* (BOL); Mosterthoek Twins, 400' [1 370 m], (–AD), 8 January 1944, *E. Wasserfall 810* (NBG), *E. Esterhuysen 9892* (BOL).

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Notes on African plants

VARIOUS AUTHORS

IRIDACEAE

ARISTEA NIGRESCENS (SUBGENUS *PSEUDARISTEA*), A NEW SPECIES FROM WESTERN CAPE, SOUTH AFRICA WITH A NOVEL STRATEGY FOR POLLINATOR ATTRACTION

INTRODUCTION

Aristea Aiton comprises ± 50 species of evergreen, rhizomatous perennials distributed through sub-Saharan Africa as far north as Ethiopia and Senegal, with seven species in Madagascar (Manning *et al.* 2002). The genus is especially diverse in the Cape Floral Region, where some 33 species are recorded. Recent advances in our understanding of morphology and relationships among the species have led to the recognition of three subgenera based on differences in fruit, seed and pollen (Goldblatt & Le Thomas 1997; Goldblatt *et al.* 2004). In contrast, the flowers of most species are very similar in form and colour, displaying little of the remarkable variability that is associated with other genera of African Iridaceae. With few exceptions, flowers of *Aristea* are rotate, uniformly deep blue, and fugacious, lasting a single morning. Significant exceptions are many species of subgenus *Pseudaristea* Pax, which is characterized by a relatively high degree of floral diversification. Subgenus *Pseudaristea* is endemic to the southwestern Cape, and is well defined by several vegetative and floral characters. The inflorescences are sessile, with large rhipidial spathes concealing the flower buds, and the ovaries are elongate and subcylindrical, maturing into elongate, 3-lobed capsules that can measure more than 80 mm long. These are thick-walled and slow to dry, remaining closed for up to a year in some species, only releasing the seeds gradually over an extended period. The distinctive seeds are triangular-columnar in shape with obliquely truncate ends, and are shortly fringed or papillate along the angles. Florally, the subgenus is characterized by prominent, deeply fringed stigma lobes, and dizonosulculate pollen that is unique for the entire Iridaceae.

Unlike other species of *Aristea*, which are pollinated by pollen-collecting bees, most species of subgenus *Pseudaristea* have developed highly specialized pollination systems, relying primarily on hopliines, or monkey beetles (Scarabaeidae: Hopliini) (Goldblatt & Manning 1997). This unusual pollination system, which is well developed in lowland habitats in the southwestern Cape, is often associated with the evolution of highly localized endemic plant species. Beetle-pollinated members of subgenus *Pseudaristea* are no exception, and the ranges of most species extend little more than 50 km and may be substantially smaller than that. The local nature of the species and their small population size puts them at high risk of extinction. In addition, the pyrophilic nature of many of the species, which flower only in the spring following a burn, means that they are rarely seen. This has led to several species being overlooked for decades or even centuries despite their proximity to well-populated areas (Goldblatt & Manning 1997). Currently, nine species are recognized in subgenus *Pseudaristea* (Manning *et al.* 2002; Goldblatt *et al.* 2005). Three of these have been described during the past decade (Goldblatt & Manning 1997; Goldblatt *et al.* 2005), all of them from well-botanized areas near large towns. The new species *Aristea nigrescens*, described here, is another example, and increases the number of species in the subgenus to ten. The species is extremely vulnerable to extinction through transformation of the habitat to agriculture.

Aristea nigrescens *J.C.Manning & Goldblatt*, sp. nov.

Plantae (100–)200–300(–500) mm altae vivaceis caespitosis, foliis linearibus 3–5 mm latis, caule angulato simplex vel raro uniramoso, inflorescentia terminali 4–6-flora, spathis late lanceolatis infra viridibus supra siccis brunneisque (10–)12–15 mm longis, floribus albis vel caeruleis, tepalis externis partim nigris nitidisque, tepalis patentibus oblique obovato-spathulatis subaequalibus vel interioribus leviter latioribus (20–)25–35 × 13–14 mm, filamentis 5–7 mm longis, antheris 6–7 mm longis, ovario cylindrico ± 10 mm longo, stylo 12–15 mm longo ecentrico, capsulis pedicellis ad 12 mm longis, cylindricis 40–50 mm longis.

TYPE.—Western Cape, 3319 (Worcester): Wolseley, Farm Romansrivier, southwestern slopes of hill above dam behind farmhouse, alluvium, (–AC), 2 September 2006, *J. Manning 3054* (NBG, holo.; K, MO, iso.).

Plants (100–)200–300(–500) mm high, evergreen, tussock-forming. *Stem* erect, angled to slightly winged, bearing two or three short, reduced leaves, simple or rarely with one axillary rhipidium. *Leaves* in a basal fan, linear, one third to ± half as long as stem, loosely twisted, 3–5 mm wide. *Inflorescence*: rhipidia, terminal or lateral, if present sessile, in axil of uppermost stem leaf, 4–6-flowered; rhipidial spathes paired, broadly lanceolate, (10–)12–15 mm long, acute, green at base but dry and papery brown in distal two thirds with paler margins, sometimes irregularly torn; floral bracts 5–7 mm long, entirely dry and papery. *Flowers* shortly pedicellate, pedicels ± 1.5 mm long, actinomorphic with style eccentric, upright, white or pale to mid-blue but paler in centre, outer tepals partially glossy blackish on reverse, lasting one day, opening mid-morning ± 10:00 and fading in afternoon ± 17:00; tepals spreading, obliquely obovate-spathulate, cucullate, connate at base for ± 1 mm, subequal or inner slightly broader, (20–)25–35 × 13–14 mm.

FIGURE 1.—*Aristea nigrescens*, *Manning 3054*. A, flowering stems and base of plant; B, fruiting stem. Scale bar: A, B, 10 mm. Artist: John Manning.

Stamen filaments suberect, straight, 5–7 mm long, white to pale blue; anthers basifixed, 6–7 mm long before anthesis, yellow; pollen yellow, grains dizonasulculate, exine reticulate. *Ovary* cylindric, ± 10 mm long, elongating rapidly after fertilization; style 12–15 mm long, white or flushed blue in distal half, dividing into three short, broad, fringed lobes 1.5–2.5 mm long. *Capsules* on pedicels up to 12 mm long, cylindric, 40–50 mm long, 3-lobed in transverse section. *Seeds* numerous per locule. *Flowering time:* late August to mid-September. Figure 1.

Distribution and ecology: a highly local endemic known from two sites along the foot of the Waaihoek Mountains overlooking the Breede River near Wolseley in Western Cape (Figure 2). Plants flower only in the season following a summer burn. At the type locality, Romansrivier Farm, the species is still abundant, occurring in large numbers in a narrow ecological zone on ferricrete, or sandstone alluvium overlying Malmesbury shale. Most plants at this locality have pale blue flowers but flower colour through the population varies from white to mid-blue. The vegetation is transitional fynbos-renosterveld. A second population located on a neighbouring farm has been reduced to just a handful of plants through cultivation of the slopes for vineyards. Both plants seen at this locality had white flowers but the small sample makes it impossible to ascertain if this was typical of the entire population. It is likely that the species once occurred in a band all along the foothills of the Waaihoek Mountains but much of the natural habitat has now disappeared under cultivation or sylviculture and the species must therefore be considered to be highly endangered.

The species is adapted to pollination by hopliine beetles (Scarabidae: Hopliini), and we observed and captured individuals of two species, *Anisonyx ditus* and *A. ursus* as frequent visitors to the flowers, which open in the mid-morning at around 10:00 and fade in the early afternoon around 15:00. The beetles crawl over the flowers, become dusted with pollen in the process and subsequently transfer it to the stigma. In the post-fire environment, *Aristea nigrescens* flowers with several other beetle-pollinated species, including *Drosera cistiflora* (Droseraceae), *Moraea versicolor, M. villosa* and *Ixia viridiflora* (all Iridaceae). These species show the characteristics of flowers adapted to this pollination system, notably a brightly coloured, salver-shaped perianth with dark central markings that act as pollinator attractants. *Aristea nigrescens* is anomalous in lacking dark markings in the centre of the flower, either on the tepals or on the stamens, and only the underside of the outer tepals is flushed blackish. The dark underside of the tepals is highly visible in the buds surrounding the open flower and in older, withered flowers, however, and the form of the buds especially is highly reminiscent of the beetles themselves. The buds in *A. nigrescens* are well exposed above the spathes for several days prior to anthesis and thus quite visible among any open flowers. In other species in the subgenus the buds are concealed among the spathes and floral bracts until the morning of anthesis. In *A. nigrescens*, therefore, it appears that the function of pollinator attraction has been transferred from the mature flower to the buds and withered flowers, which

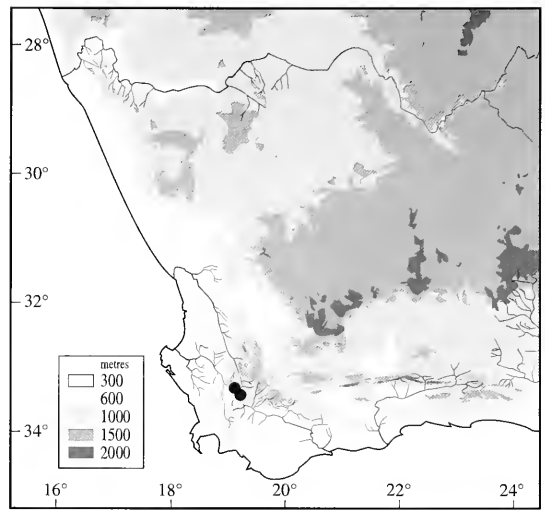

FIGURE 2.—Known distribution of *Aristea nigrescens*.

thus act as accessory pollinator attractants. The use of accessory structures for pollinator attraction has been identified in several southern African bird-pollinated taxa: floral buds and immature flowers function as accessory floral attractants in bird-pollinated species of *Melianthus* (Melianthaceae) (Linder *at al.* 2006), and in Iridaceae the inflorescence spathes in *Klattia* or the floral bracts in certain species of *Gladiolus* such as *G. abbreviatus* (Goldblatt *et al.* 1999) play a similar role. This is the first record, however, of secondary pollinator attraction among insect-pollinated members of the Iridaceae. A distinct indole-dominated fragrance was detected at anthesis in a single flower, fading within an hour or so, but investigation of several other stems failed to detect any scent and this remains an anomalous observation.

Diagnosis and relationships: *Aristea nigrescens* is characterized by unbranched stems bearing a solitary, terminal flower cluster, or very rarely with a single second cluster in the axis of the upper stem leaf; broadly lanceolate rhipidial spathes, (10–)12–15 mm long, that are papery brown in the distal two thirds; and by its large, white to blue flowers without dark markings. The underside of the outer tepals is flushed blackish and the buds thus appear dark. In its unbranched stems and broad, rather blunt rhipidial spathes, the species resembles *A. lugens* (L.f.) Steud. and it is likely that the two are allied. *Aristea lugens* is distinguished by its strongly dimorphic tepals, with the outer tepals ± half as long as the inner and dark brown or black over most of the surface and strongly incurved, exposing both upper and lower surfaces. Thus *A. lugens*, like *A. nigrescens*, utilizes the underside of the tepals for pollinator attraction but, unlike the latter, only in the mature flower and not in bud. Other species in subgenus *Pseudaristea* typically have branched stems bearing several lateral flower clusters and smaller, acute or acuminate rhipidial spathes that are ± entirely leathery and green.

Other material examined

WESTERN CAPE.—3319 (Worcester): Wolseley, Waaihoek Road, Silver Leaf Mountain Vineyards, (–CB), 12 September 2006, *J. Manning & P. Goldblatt 3055* (MO, NBG).

ACKNOWLEDGEMENTS

Thanks to Rupert Koopman for alerting us to the species. Material was gathered with a permit from Western Cape Nature Conservation on a trip sponsored by Elizabeth Parker. Mr Lategaan was kind enough to allow us to visit his farm.

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MS. received: 2007-01-09.

IRIDACEAE

NIVENIA ARGENTEA MISUNDERSTOOD, AND THE NEW SPECIES *NIVENIA INAEQUALIS* (NIVENIOIDEAE)

INTRODUCTION

The genera *Nivenia* Vent. (10 spp.), *Klattia* Baker (3 spp.) and *Witsenia* Thunb. (1 sp.) are the only truly shrubby members of the family Iridaceae, and comprise the monophyletic subfamily Nivenioideae (Goldblatt *et al.* in press). All are endemic to the southwestern Cape, South Africa, and were recently monographed by Goldblatt (1993). Since then a single additional species, *Nivenia parviflora* Goldblatt, has been described (Goldblatt 1997). Species of *Nivenia* are largely restricted to montane habitats at middle elevations and most are narrow local endemics, occurring on a single mountain range or at most on adjacent ranges. A striking exception is *N. argentea* Goldblatt, which was until now considered to occur on both the coastal Langeberg and Riviersonderend Mtns as well as inland on the Rooiberg range in the Little Karoo (Goldblatt 1993). Our current knowledge of this species, however, was based almost entirely on the populations from the Rooiberg, which are readily accessible by road.

In May 2005 an unidentified *Nivenia* was photographed on the Riviersonderend Mountains by plant enthusiast David Gwynne-Evans. The photographs showed a species with the congested, pseudoracemose inflorescence typical of *N. argentea* but the dark (rather than pale) blue flowers appeared to lack the short, suborbicular style arms that were regarded as characteristic of that species, as well as the conspicuous silvery bracts that gave the species its name (Goldblatt 1993). In addition, the inflorescence appeared to be well exserted from the leaf cluster, unlike the Rooiberg populations in which it is typically only shortly extended beyond the leaves. The form of the inflorescence in the Riviersonderend plants is, however, a close match for the Langeberg populations of *N. argentea*, as well as the type of the species, which was collected on the Riviersonderend Mtns.

Further examination of the Langeberg material at our disposal raised the strong possibility that it was not in fact conspecific with the Rooiberg collections after all, although most specimens available lacked well-preserved flowers. Efforts were therefore made to obtain good flowering material of the Langeberg or Riversonderend plants and in December 2006 members of the Friends of the Outeniquas, under the guidance of Di Turner, succeeded in locating ample flowering plants. The following year Martin Grantham secured material from both the Langeberg and Riviersonderend Mountains. These collections confirm that the Langeberg and Riviersonderend plants are a close match for the type of *Nivenia argentea* and are distinct from the Rooiberg populations.

This confirms that *Nivenia argentea* is typical of the other members of the genus in having a limited distribution and that the Rooiberg populations comprise an undescribed species that we name *N. inaequalis,* for the markedly unequal stamens that characterize the species. We also provide a full description of true *N. argentea*, flowers and fruits of which have not been available for detailed examination until now.

Nivenia now comprises 11 species, all of rocky sandstone habitats in the southern African winter rainfall zone. Of these, seven species are distylous and four are homostylous.

Nivenia argentea *Goldblatt*, The woody Iridaceae: 54 (1993), as a substitute name for *Nivenia capitata* (Klatt) Weim.: 366 (1940), nom illeg. non *N. capitata* R.Br. (Proteaceae). *Witsenia capitata* Klatt: 546 (1866). Type: South Africa, [Western Cape], banks of the Riviersonderend,

Appelskraal, Eksteen, and surrounding mountains, 500–4000' [150–1 200 m], *Ecklon & Zeyher Irid. 62* (B, holo.; MO!, S!, iso.).

Rounded shrubs up to 400 mm high, branching from base, forming dense cushions. *Stems* ascending, compressed, leafy portions 2–4 mm diam. *Leaves* crowded apically, linear-lanceolate, (20–)40–80 × 1.5–3.0 mm. *Inflorescence* a congested, branched pseudoraceme, up to 15-flowered, lateral branches short, 3-flowered, each node bearing a short-stalked, 1-flowered rhipidium; peduncle axis compressed, extending (10–)20–40 mm from leaf cluster, ultimate branches ± 2 mm long; inflorescence bracts lanceolate-attenuate, keeled, outer bracts 15–25 mm long, dry and brown with brown membranous margins, inner bracts about two thirds as long as outer, with narrow transparent membranous margin; spathes tightly enclosing flower, lanceolate-attenuate, 13–18 mm long, dry and papery, brown below and in midline, margins and apices transparent-membranous; floral bracts tubular, 18–25 mm long, dry and membranous, usually silvery transparent in upper half or third, brown in lower half to two thirds, sometimes ± entirely shining brown, becoming torn apically. *Flowers* salver-shaped, heterodistylous, deep blue, darker in centre and white in throat and tube; perianth tube 14–20(–25) mm long, widening gradually towards mouth; tepals oblong-oblanceolate, 13–18 × 4–6 mm, spreading. *Stamen filaments* inserted in mouth of tube, either 4–5 mm long (thrum flower) or 1.0–1.5 mm long (pin flower); anthers 1.0–1.5 mm long before anthesis, yellow; pollen yellow. *Ovary* ± 1.5 mm long; style either included 0.5–4.0 mm below mouth of tube (thrum flower) or exserted ± 7 mm and reaching ± 5 mm beyond anthers, dividing into filiform branches ± 1.5 mm long. *Capsules* obovoid, 6–7 × 3–4 mm, typically with just a single fertile locule containing a solitary seed. *Seeds* one per locule, ± 4.5 × 1.8 mm, scutiform, papillate-rugulose. *Flowering time*: mainly October to December, occasionally out of season in March and April. Figure 3.

Distribution and ecology: a montane species occurring at middle to upper elevations, 500–1 000 m, along the Riviersonderend and adjacent Langeberg Mountains (Figure 4), *Nivenia argentea* has been recorded from the eastern Riviersonderend Mtns above the town of Riviersonderend and from several sites along the southern length of the Langeberg, from Tradouwberg and Grootvadersbos north of Heidelberg in the west to Garcia's Pass and Paardeberg near Riversdale in the east. Plants grow on exposed, rocky ridges, forming densely leafy, rounded shrubs up to 400 mm high. Populations are usually small.

Diagnosis and relationships: *Nivenia argentea* is distinguished by its congested, pseudoracemose inflorescence with lanceolate-attenuate subtending bracts that are entirely brown and dry. The ultimate branches bear single-flowered rhipidia, and each flower is surrounded by a tubular bract 18–25 mm long that is dry and membranous, usually silvery transparent in the upper half and brown in the lower half but sometimes entirely shining brown. The species is heterodistylous, as are most species of *Nivenia,* and the flowers have a perianth tube 14–25 mm long with the anthers exserted on filaments either 4–5 mm long (thrum flowers) or 1.0–1.5 mm long (pin flowers). The style branches are slender and typical of most other species in the genus, and differ from those of *N. inaequalis*, which are short and rounded.

In the structure of the compound inflorescence *Nivenia argentea* closely resembles *N. inaequalis* from the Rooiberg but in this species the inflorescence bracts and spathes have broad, silvery margins and the floral bracts are entirely silver-transparent. The rhipidia in *N. inaequalis*, unlike those of *N. argentea*, are 2-flowered and the flowers themselves are distinctive in their longer tubes, 30–40 mm long vs 14–20(–25) mm long in *N. argentea*; in their unequal stamens in which one filament is notably shorter than the other two; and in the unique, short, rounded style branches. The tubular floral bract of *N. argentea*, in which the lower margins are fused to form a closed cylinder (Figure 3F), have not been recorded in the genus before. The bract margins in *Nivenia* species are usually free to the base, although overlapping and enclosing the perianth tube. Closer examination of the bracts of the remaining species reveals that *N. fruticosa* (L.f.) Baker, also from the Langeberg Mountains, is the only other species with tubular floral bracts, possibly indicating a close relationship between it and *N. argentea*.

History: *Nivenia argentea* has been misunderstood almost since its first description by F.W. Klatt in 1866, and its early history has been well documented by Goldblatt (1993). First described under the name *Witsenia capitata*, the species was based on immature specimens collected in bud by C.F. Ecklon & C.L. Zeyher in the Riviersonderend Mountains. Although subsequently included in a second species, *N. fruticosa*, by both J.G. Baker (1877, 1896) and N.E. Brown (1933), the species was later resuscitated by Weimarck (1940), unfortunately under the illegitimate combination *Nivenia capitata* (Klatt) Weim., a homonym for *N. capitata* R.Br. [now *Paranomus capitatus* (R.Br.) O.Kuntze, Proteaceae]. By this time, further specimens from Garcia's Pass in the Langeberg had been collected by E.E. Galpin in 1897, enabling Weimarck to describe the flowers more fully. Weimarck's illustration (1940: fig. 2A) clearly shows the extremely short filaments (of the pin morph), and his interpretation of the inflorescence as comprising several solitary flowers led him to place the species in his section *Singulares*, erected for those taxa with single-flowered rhipidia. The species remained poorly collected, however, and it is thus not surprising that when a *Nivenia* species with a similar congested, pseudoracemose inflorescence and silvery floral bracts was collected in 1957 from the Rooiberg in the Little Karoo, inland of the Langeberg, it was referred to the same species (Goldblatt 1993). The Rooiberg locality is easily reached by vehicle and plants from there thus served as the basis for the description and fine illustrations that appeared under the new name *N. argentea* Goldblatt, coined to replace the illegitimate *N. capitata* (Goldblatt 1993). In the absence of any further collections of the species from west of the Langeberg, Goldblatt followed Weimarck in concluding that the locality of the type collection on the Riviersonderend Mountains was most probably incorrect. More recent collections of the species from the Langeberg, largely lacking flowers, did nothing to change this interpretation but the photographic evidence of plants from the

FIGURE 3.—*Nivenia argentea, Custodians of Rare and Endangered Wildflowers s.n.* A, two flowering branches; B, outer inflorescence bract; C, inner inflorescence bract; D, single rhipidium; E, spathes; F, floral bract; G, floral bract flattened; H, pin flower flattened; I, thrum flower flattened; J, style branches. Scale bars, A–I, 10 mm; J, 1 mm. Artist: John Manning.

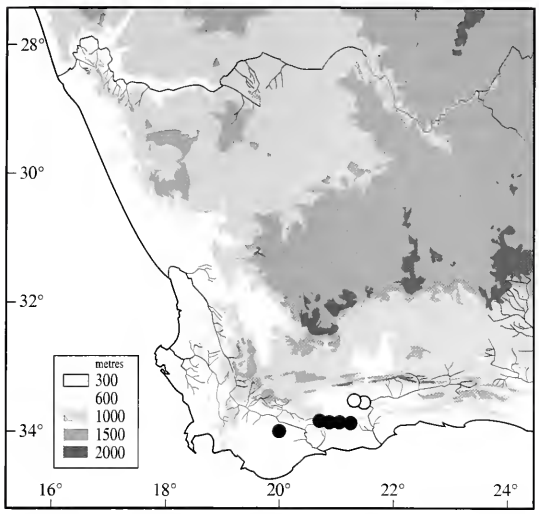

FIGURE 4.—Known distribution of *Nivenia argentea*, ●; *N. inaequalis*, ○.

Riviersonderend Mountains suggests that the type locality of the species is indeed this mountain range.

The name *Nivenia argentea* is thus correctly applied only to the populations of the species from the Langeberg and Riviersonderend Mountains, and the Rooiberg populations represent an unnamed species that we describe here as *N. inaequalis*.

Other material seen

WESTERN CAPE.—3320 (Montagu): Swellendam, Tradouwberg, (–DD), without date, *J. Bowie s.n.* (K); Langeberg East MCA, Compartment 8, S slopes of Horingberg, 3800' [1 160 m], (–DD), December 1984, *T.J. van der Merwe 31* (NBG, WICHT). 3321 (Ladismith): Garcia's Pass, (–CC), October 1926, *C. Thorne SAM38856* (NBG, SAM); Garcia State Forest Reserve, approaching Aasvoelkrans, 1 151 m, (–CC), 18 December 1988, *D.J. McDonald 1797* (NBG); Garcia Forest Reserve, Rooiwaterspruit overlooking Oudebosch, 600 m, (–CC), 21 November 1991, *D.J. McDonald 2107* (NBG); near Rooiwaterspruit huts, (–CC), 9 January 2007, *M. Grantham s.n.* (NBG); mountains at Garcia's Pass, (–CC), 2 October 1897, *Galpin 4664* (PRE), October 1931, *M.A. Pocock s.n.* (BOL); southern slope next to path from Rooiwaterspruit huts heading east, about 1 km from huts, 517 m, (–CC), 13 December 2006, *Custodians of Rare and Endangered Wildflowers s.n.* (MO, NBG); Sandkraal, Rooielsberg, (–CD), 5 December 1982, *Viviers 292* (PRE); northern Langeberg, northeast of Langkloof, 2 km west of Waterval Peak and 12 km east of Garcia's Pass, 1 100 m, (–CD), 3 July 2000 (fr.), *N.A. Helme* 1730 (NBG); eastern Langeberg, summit ridge 1.5 km west of Doodkisberg, 900 m, (–DC), 29 April 2006, *N.A. Helme 3922* (NBG); summit ridge of Perdeberg [Paardeberg], northwest of Bergfontein Farm, 1 120 m, (–DC), 27 April 2001, *N.A. Helme 1972* (NBG). 3420 (Bredasdorp): eastern Riviersonderend Mtns, 34°05'41.7"S 19 °55'47.5"E, (–BB), 17 January 2007, *M. Grantham s.n.* (NBG). Without precise locality: Cape of Good Hope, *J. Niven s.n.* (BM), *W. Roxburgh s.n.* (BM); 'very high in the Swellendam Mountain', *Mackrill s.n.* (BM).

Nivenia inaequalis *Goldblatt & J.C.Manning*, sp. nov.

Nivenia argentea sensu Goldblatt (1993), in part.

Plantae 400–800 mm altae, sempervirentes, caulibus pluribus e caudice lignoso compressis ellipticis, foliis distichis anguste lanceolatis (40–)55–90 × 2–3 mm, inflorescentia composita ex rhipidiis binatis bifloris in pseudoracemum congestum dispositis constanter, spathis 13–15 mm longis, bracteis siccis papyraceis albotranslucentibus, floribus caeruleis sessilis heterodistylis, tubo perianthii 30–40 mm longo, tepalis patentibus lanceolato-ellipticis ± 18 × 5–6 mm, filamentis 7–8 mm longis (plantis brevistylis) vel 3 mm longis (plantis longistylis), antheris 1.0–1.5 mm longis flavis, ovario ± 1.5 mm longo, stylo in tubo incluso (plantis brevistylis) vel 6–8 mm exserto (plantis longistylis), lobulis styli 0.5 mm longis.

TYPE.—Western Cape, 3321(Ladismith): Rooiberg Mtns, next to forestry track near Bailey's Peak, 3300–4600' [1 000–1 400 m], (–CB), 29 December 1986, *J.H.J. Vlok 1794* (NBG, holo., K, MO, PRE, iso.).

Rounded evergreen shrubs, 400–800 mm high, branching from base. *Stems* ascending, with short spur-shoots in upper part, leafy portions ± 3 mm diam. *Leaves* crowded apically, narrowly lanceolate, (40–)55–90 × 2–3 mm. *Inflorescence* a congested, branched pseudoraceme, up to 20-flowered, lateral branches short, each node bearing a short-stalked, 2-flowered binate rhipidium; peduncle axis compressed, exserted (10–)15–30 mm from leaves, ultimate branches 3–4 mm long; inflorescence bracts lanceolate-attenuate, keeled, outer bracts ± 17 mm long, dry and white-translucent with brown midline, inner bracts white-translucent membranous and somewhat shorter; spathes tightly enclosing flower, lanceolate-attenuate, 13–15 mm long, dry and membranous, brown below and in midline, margins white-transparent; floral bracts enveloping tube, open to base, 22–25 mm long, dry and white-translucent throughout, becoming torn apically. *Flowers* salver-shaped, heterodistylous, blue, darker at tepal bases and white in throat and tube; perianth tube 30–40 mm long, widening gradually towards mouth; tepals elliptic-lanceolate, ± 18 × 5–6 mm, spreading. *Stamen filaments* inserted in mouth of tube, unequal with one shorter than others, either two 7–8 mm long and one ± 5 mm long (thrum flower) or two 3 mm long and one 1.5–2.5 mm long (pin flower); anthers 1.0–1.5 mm long before anthesis, yellow; pollen yellow. *Ovary* ± 1.5 mm long; style either included 2–3 mm below mouth of tube (thrum flower) or exserted 6–8 mm and reaching 2–4 mm beyond anthers, dividing into rounded lobes 0.5 mm long. *Fruit* a subglobose capsule, ± 6 × 4.0–4.5 mm. *Seeds* one per locule, shield-shaped, rugose, ± 4.5 × 3.5 mm. *Flowering time*: mainly November and December, occasionally out of season in February and March.

Distribution and ecology: *Nivenia inaequalis* is restricted to the upper reaches of the Rooiberg (Figure 4), an isolated massif southeast of Ladismith, where it occurs above 1 000 m on rocky ridges and summits in arid fynbos, usually in exposed sites in rock outcrops.

Diagnosis and relationships: *Nivenia inaequalis* is instantly recognized in the genus by its unequal stamens, with one filament shorter than the other two, and by the short, rounded, rather than linear or ± filiform style branches. The species is heterodistylous and in the pin morph the shorter stamen is included in the elongate perianth tube, which is 30–40 mm long. The floral bracts are very conspicuous, being silver-translucent throughout their length.

Nivenia inaequalis is most likely to be confused with *N. argentea* from the Langeberg and Riviersonderend

Mountains. Both species have a similar general aspect, forming rounded, leafy, cushion-like shrubs, and similar dry, lanceolate-attenuate bracts and a distinctive, compact, pseudoracemose inflorescence. This inflorescence type, however, is probably ancestral, being matched among the woody Iridaceae in *Witsenia* and, moreover, most like the inflorescence of *Aristea*, which is sister to the Nivenioideae–Crocoideae clade (Reeves *et al.* 2001). The 2-flowered, binate rhipidia of *N. inaequalis* represents the ancestral condition, whereas the single-flowered rhipidia of *N. argentea* are clearly derived. *Nivenia argentea* also differs from *N. inaequalis* in its slightly shorter perianth tube, 14–25 mm long, and specialized tubular bracts that are partially or completely brown. The equal stamens and linear style branches of *N. argentea* are unspecialized in the genus.

History: although first collected by T.M. Wurts in 1957, *Nivenia inaequalis* was invariably confused with *N. argentea* Goldblatt, and the fine illustrations published under the name *N. argentea* in *The woody Iridaceae* (Goldblatt 1993) actually represent this species.

Other material seen

WESTERN CAPE.—3321 (Ladismith): crest of Rooiberg west of Rooiberg Pass, 3600' [1 100 m], (–CB), 13 November 1957, *T.M. Wurts 1618* (NBG); Rooiberg crest road, 1 159 m. (–CB), 10 May 1983, *A.H. Marshall 30* (NBG); Ararat Ridge, 4100' [1 250 m], (–CB), 18 December 1977, *H.C. Taylor 9773* (NBG); south-facing slopes approaching Mount Ararat, 900 m, (–CB), 15 December 1989, *D.J. McDonald 1903* (NBG); upper north slopes of Rooiberg, forestry track, (–CB), 12 February 1997, *P. Goldblatt 10614* (MO); ridge west of Teeboskop above Assegaaiboskloof, 3000' [915 m], (–DA), 9 November 1974, *E.G.H. Oliver 5351* (NBG, PRE); Teeboskop area, 3000' [915 m], (–DA), 2 November 1987, *P. Goldblatt & J.C. Manning 8558* (MO, NBG).

ACKNOWLEDGEMENTS

We thank David Gwynne-Evans for alerting us to the existence of plants later found to be *Nivenia argentea* in the Riviersonderend Mountains, Jan Vlok for assisting in locating living plants from the Langeberg, plant enthusiasts Di Turner and the Friends of the Outeniquas for collecting plants and forwarding them to us for study, and Martin Grantham for visiting the populations to secure capsules and seeds.

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MS. received: 2007-01-09.

BORAGINACEAE

LOBOSTEMON LASIOPHYLLUS: DISCOVERY OF A LINK SPECIMEN IN STOCKHOLM, THE CORRECT AUTHOR CITATION AND SYNONYMY

Retief (2003), following Levyns (1934), cited *Lobostemon lasiophyllus* DC. as a synonym of *L. fruticosus* (L.) H.Buek. Link (1821) described *Echium lasiophyllum* as new and De Candolle (1846) accepted the species and transferred it to *Lobostemon*, whence the correct author citation must be *L. lasiophyllus* (Link) DC. The view that *L. lasiophyllus* is a synonym of *L. fruticosus* can be questioned when the characters mentioned in the protologue such as calyx lobes as long as corolla, corolla white and style glabrous are contemplated. These do not characterize *L. fruticosus*, but rather *L. trichotomus* (Thunb.) DC. However, the leaf width given (6 lines wide, i.e. ± 12 mm) excludes *L. trichotomus* again, which typically possesses leaves (1.0–)1.5–3.5(–5.0) mm wide; *L. fruticosus* possesses leaves (4–)5–10(–12) mm wide. In addition, reference to 'Folia ... basi attenuata' reminds us of the oblanceolate or obovate leaves found in *L. fruticosus* and not the narrowly oblong to lanceolate leaves of *L. trichotomus*.

According to Stafleu & Cowan (1981), Link's types were all housed in Berlin (B), but no specimens pertaining to *Echium lasiophyllum* exist there—these were destroyed in World War II. Link material also exists in a number of other places, but all attempts to find relevant specimens have failed for the herbaria listed in Stafleu & Cowan (1981).

Link presumably considered *Echium longifolium* Delile (1813) a barrier to his publishing '*E. longifolium* (ex hort.)' and supplied a new name, *E. lasiophyllum* to avoid homonymy. Wright's (1904) and the International Plant Name Index (2004) reference of the authorship of *E. longifolium* as 'hort. ex DC.' is considered incorrect because Dc Candolle (1846: 10) merely cites '*E. longi-*

folium (ex hort.)' as a synonym of *L. lasiophyllus*. No material labelled '*E. longifolium* hort.' has been found either.

However, in the Swedish Museum of Natural History (S) there is a specimen associated with Link and which can shed light on the identity of *E. lasiophyllum*. It is a single flowering specimen with an old, small handwritten label in two different hands. In fainter ink there is: 'Echium lasio... Link Enumerat'. Only 'lasio' in the epithet is clearly written, the rest is a wavy line indicating a longer name (*lasiophyllum*). Another hand has added in darker ink: 'ded Otto Berol 1823' (Figure 5).

We believe the first writer is J.H.F. Link himself. His way of writing his own name is characteristic, especially with the enlarged 'K' in 'Link'. The second writer is J.G.C. Lehmann. Apparently C.F. Otto provided Lehmann in Hamburg with this specimen from Berlin. The reference to 1823 is probably the date of acquisition of the specimen by Lehmann, and not the date of collection ('dedit' = given by, furnished by). Christoph Friedrich Otto (1783–1856) was long active at the Berlin Botanic Garden and Museum (B), appointed first as gardener and inspector by Willdenow in 1805 and he became a close collaborator with Link up to the year 1843. According to Hiepko (1987), Link's herbarium, purchased by B after his death in 1851, contained many type specimens from the botanical garden. Although there is no evidence that the specimen in S was made from the cultivated plant on which Link based the new name, it gives an indication of the taxonomic identity because of the label in Link's hand. A perusal of collections in S suggests that this is a unique case of a specimen associated with Link having found its way there via Hamburg.

FIGURE 5.—Neotype in S of *Echium lasiophyllum* Link, annotated by J.H.F. Link and J.G.C. Lehmann.

Echium lasiophyllum *Link* in Enumeratio plantarum horti regii botanici berolinensis altera 1: 170 (1821). *Lobostemon lasiophyllus* (Link) DC.: 10 (1846); C.H. Wright: 42 (1904). Neotype (here designated): ex hort., *Otto s.n.* (*S-06-4728*!).

This specimen agrees with *L. fruticosus* as currently understood on account of its oblanceolate to obovate leaves possessing dimorphic hairs as well as infundibular flowers with hairs on the abaxial corolla surface. The discrepancy in the protologue mentioned above cannot be accounted for.

Details of the accepted name are:

Lobostemon fruticosus *(L.) H.Buek* in Linnaea 11: 134 (1837). *Echium fruticosum* L.: 139 (1753). Lectotype (Buys & Van der Walt in Taxon 45: 515. 1996): [icon] '*Echium Africanum frutescens foliis pilosis*' in Commelin, Horti Med. Amstelod. 2: 107, t. 54 (1701).

ACKNOWLEDGEMENTS

We thank Johannes Lundberg (S) for providing digital images of the specimen in question and the curators of BR, C, FI, H, LIV, P, PH and W for assisting us in searching for original material. We are grateful to John McNeill for useful comments on the manuscript.

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MS. received: 2006-06-23.

PEDALIACEAE

DEWINTERIA, A NEW SEMISUCCULENT, CLIFF-DWELLING GENUS ENDEMIC TO THE KAOKOVELD, NAMIBIA

While studying cremnophilous plants in the northern Namib Desert (Kaokoveld), Namibia, specimens of the hitherto poorly known *Rogeria petrophila* De Winter, a small, herbaceous and semisucculent chasmo-cremnophyte, were collected in July 2002 and January 2005. This enabled us to record, for the first time, the reproductive behaviour of the species in its natural cliff-face habitat, and to collect ample sterile and reproductive material for a comparative morphological study. A re-evaluation of the taxonomic position of the species was considered necessary in the light of its unique dimorphic fruiting capsules, texture and morphology of the seeds and specialized filiform basal branches by which it differs markedly from the other three species of *Rogeria*. We concluded that *R. petrophila* warrants separate generic status and it is here formally described as a new monotypic genus.

Dewinteria *Van Jaarsv. & A.E.van Wyk*, genus novum, *Rogeriae* J.Gay ex Delile affine, sed differt characteribus sequentibus: *herba* biennis vel perennis, saepius caulibus procumbentibus 100–200 mm longis. *Folia* cordata, margine grosse dentato. *Capsula* 2.0–2.5 mm longa, lateraliter compressa chartacea. *Semina* 2.0–2.2 mm longa, anguste oblonga ad clavata, leviter lateraliter compressa, pagina minuta reticulata. Ad basim rami filiformes 0.25 mm diametri, ad 200 mm longi, ferentes folia integera ovata 2–4 × 0.6–1.7 mm, et flores axillares cleistogamos, 2 mm longos et capsulas complanatas ovatas ad ovato-cordatas 5–8 × 4.0–5.5 mm; semina linearioboyoidea 2.5–3.0 mm longa.

Type species: *D. petrophila* (De Winter) Van Jaarsv. & A.E.van Wyk.

Rogeria J.Gay ex Delile subgen. *Microrogeria* Ihlenf.: 73 (1967).

Description partly based on De Winter (1961).

Soft, somewhat trailing, branched, biennial or perennial herb, up to 200 mm long; most parts covered with mucilage glands; base of stem slightly swollen, semisucculent, somewhat ovate, up to 5 mm diam., often compressed due to narrow crevices. *Roots* fibrous. *Main branches* 3–4 mm diam. at base. *Specialized branchlets* annual, usually dying back after fruiting, filiform, 0.25 mm diam., basally produced, trailing, negatively phototropic. *Leaves on main branches* opposite (internodes 8–14 mm long), broadly cordate to kidney-shaped, up to 40 × 55 mm, grey-green; margin coarsely dentate; petiole 20–60 mm long; mostly with a paired or single extrafloral nectary in the axil. *Leaves on specialized branchlets* (arise as accessory shoots below the extrafloral nectary and flower) small, 2–4 × 0.6–1.7 mm, entire, ovate; petiole 3–4 mm long, sometimes becoming slightly longer but then leaves becoming broader and coarsely toothed.

Flowers on main branch in axils of leaves, mostly single, rarely in pairs, conspicuous, trumpet-shaped, up to 30–70 mm long; pedicel 1.2–4.0 mm long. *Calyx* slightly zygomorphic, persistent, 5-partite; lobes oblong-triangular, up to 3 mm long. *Corolla* slightly swollen at base, somewhat 2-lipped, sparsely covered with mucilage glands; cream-coloured (pale yellow in bud stage) and maroon-purple in throat and tube; lobes 5, broadly ovate, emarginate, lower pair slightly larger than upper 3. *Stamens* 4, arising from base of corolla tube, with short staminode between the pairs; filaments filiform, slightly flattened, up to 12 mm long, pilose; anthers basifixed. *Ovary* elongate-conical, 2-chambered, placentation axile, with 3–5-seriate ovules; style up to 23 mm long; stigma capitate, up to 1.5 mm diam. *Cleistogamous flowers on specialized branchlets*, 2 mm long, light yellowish green; pedicels up to 1.5 mm long. *Capsules on main branches* lanceolate in side view, 18–25 mm long, tapering into a curved apex, laterally flattened, dehiscing loculicidally; valves 2, chartaceous. *Specialized capsules* flattened, ovate to ovate-cordate, 5–8 × 4.0–5.5 mm, brown; both carpels dehiscing loculicidally, false septa nearly completely reduced to small seams at base of capsule. *Seeds of main branch capsules* linear-oblong to club-shaped, slightly flattened, 2.0–2.2 mm long, minutely foveate, brownish. *Specialized seeds* oblong-obovoid, slightly flatened, 2.5–3.0 mm long, minutely fringed. Figures 6–8.

The new genus is named in honour of Dr Bernard de Winter, retired Director of the former Botanical Research Institute in Pretoria (now part of the South African National Biodiversity Institute), who collected and described *Rogeria petrophila* and who first mentioned the possibility of fruit dimorphism in this species (De Winter 1961).

The genus includes a single species:

Dewinteria petrophila *(De Winter) Van Jaarsv. & A.E.van Wyk*, comb. nov.

Rogeria petrophila De Winter in Kirkia 1: 106–108 (1961). Type: South West Africa [Namibia] 1712 (Orokatuwo): Kaokoveld, 30 miles S of Kunene River on road to Orupembe, (–DA), 10-05-1957, *De Winter & Leistner 5790* (PRE, holo.; K, M, SRGH, iso.).

Description as for genus.

DISCUSSION

Distribution and ecology: *Dewinteria petrophila* is a semisucculent, biennial or perennial chasmo-cremnophyte, at present only known from crevices and fissures on granite cliffs of the Otjihipa Mountains in the western Kaokoveld of northern Namibia (Figure 9). It grows on all aspects but is more abundant on south-facing ones and at altitudes of about 600–1 700 m on the northwestern peaks of these mountains (eastern margin of the Marienfluss). The upper slopes receive fog and are cooler, with Cape floristic elements such as species of *Eriocephalus*, *Othonna* and *Pelargonium*. The average annual rainfall in the Kaokoveld varies from less than 50 mm along the coast to 350 mm in the highlands (Mendelsohn *et al.* 2002). This species is a constitu-

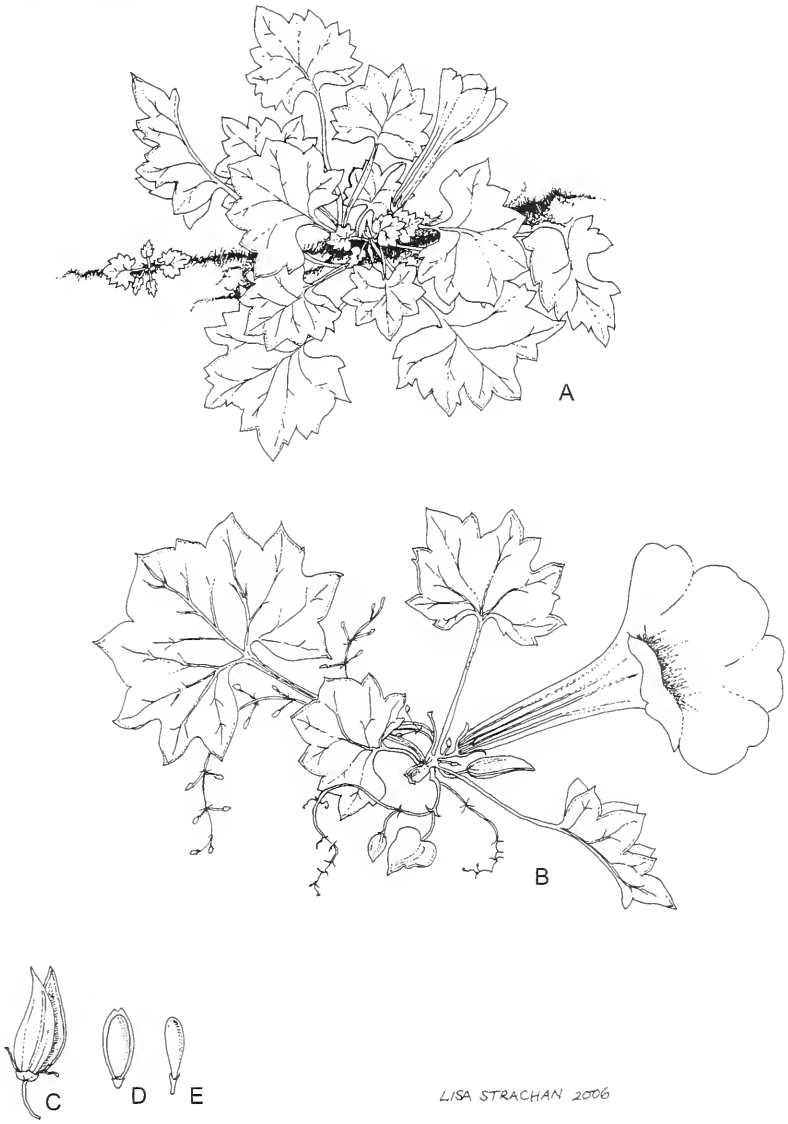

FIGURE 6.—*Dewinteria petrophila*: A, plant growing in crevice, × 0.7; B, plant in flower, with stem bearing normal flowers and fruiting capsule as well as thread-like branchlets, × 0.7; C, normal fruiting capsule, × 0.7; D, specialized seed, × 5; E, normal seed, × 5. Artist: Lisa Strachan.

ent of arid *Colophospermum mopane* woodland, with several species of *Commiphora* prominent. It shares its habitat with other cremnophytes such as *Aeollanthus haumannii*, *Kalanchoe lanceolata*, *Plectranthus dinteri* and *Tetradenia kaokoensis*. The range of *D. petrophila* almost certainly extends to the adjacent high mountains of southwestern Angola, especially the botanically poorly known Serra Cafema range just north of the Otjihipa Range. *Dewinteria* is one of about seven genera endemic to the Kaokoveld Centre of Endemism, a biogeographical region in arid northwestern Namibia and adjacent southwestern Angola (Van Wyk & Smith 2001).

Cliffs provide a stable, safe environment for plants in the absence of larger herbivores and there is often a defence relaxation tendency (disarmament) in obligate cliff dwellers (Van Jaarsveld & Van Wyk 2003). However, the vertical habitat (extreme water runoff) and a lack of space to grow, demand a shift in habit and reproductive output. This often results in specialist features such as succulence, compact growth form, dwarf clustering, cylindrical shape, pendent habit, profuse flowering and an increase in vivipary (vegetative reproduction) (Snogerup 1971; Van Jaarsveld & Van Wyk 2003). There is also a shift towards wind-dispersed seed (anemochory).

In his original description of *Rogeria petrophila*, De Winter (1961) mentions thread-like branches and smaller capsules of which the function was uncertain. His surmise is correct. *Dewinteria petrophila* does have a remarkable and unique dimorphic facultative reproduction strategy—an adaptation that helps it to survive under the extreme desert conditions of its cliff habitat. In addition to its conventional aerial branches bearing insect-pollinated flowers and wind-dispersed seeds, it produces specialized shoots that are negatively phototropic, entering hairline cracks and other crevices. These bear small cleistogamous flowers with ± heart-shaped capsules with fewer but larger, differently shaped seeds

FIGURE 7.—*Dewinteria petrophila* in flower in a fissure on granite cliffs of the Otjihipa Mountains in northwestern Namibia.

(Figures 6, 8). This unique adaptation ensures that seeds are buried deep into crevices near the mother plant.

Dewinteria petrophila displays a unique amphicarpous condition, with both atelechorous and anemochorus dispersal methods. This is a remarkable adaptation and the first of its kind recorded for an obligate cliff-dwelling species. Its larger seeds are a self-preserving strategy, ensuring its long-term survival in its present habitat. This atelechorous seed dispersal ensures self-cloning, and the normal smaller anemochorous seeds (from insect-pollinated flowers) ensures interbreeding and dispersal to new sites. The larger seed carries larger reserves that the seedling needs after germination. The thread-like branches in the crevices ensure an almost 100% survival rate if the mother plant should die owing to drought or natural causes. The smaller capsules produce about five or fewer seeds per capsule, whereas the normal and larger aerial seed capsules produce more than 50 seeds per capsule. Winds on the cliffs are often strong and updrafts ensure the seeds' effective dispersal to other crevices. *D. petrophila* flowers in the rainy season, dispersing its seeds in autumn. Seeds are covered with mucilage, which is often associated with plants from desert or semi-desert regions, helping to anchor the seeds to the substrate (Van der Pijl 1982).

Systematic affinities: the genera of the Pedaliaceae (a small family of ± 13 genera and 70 species, mostly African) are delimited largely by their fruit type (Ihlenfeldt 1964, 1967; Kadereit 2003). They occur mainly in semi-arid and arid habitats of the Old World tropics (Smithies & Herman 2003). Life forms in the family are remarkably diverse, varying from erect annuals or biennials (*Rogeria*), trailing perennials (*Dicerocaryum*), thickset chamaephytes (*Pterodiscus*), to dwarf trees (*Sesamothamnus*). Members have mainly opposite leaves and attractive, gamopetalous, tubular flowers, the pedicels bearing characteristic extrafloral nectar glands at the base. The fruits are very diverse, varying from winged to heavily armoured capsules, that are dehiscent or indehiscent. Mucilage glands are common in the family. Perhaps the best known member is

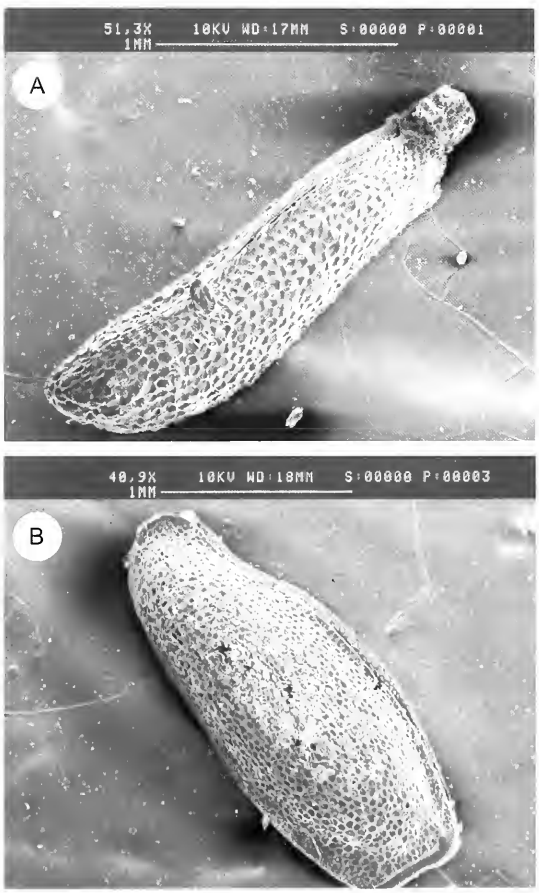

FIGURE 8.—*Dewinteria petrophila*, *Van Jaarsveld & Swanepoel 19413*: A, normal seed; B, specialized seed (SEM).

Harpagophytum, a tuberous-rooted trailing plant of the Kalahari, used world-wide as a medicine for arthritis (Van Wyk *et al.* 1997). Plants of the genus *Rogeria* (three species and exclusive to Africa) are robust, erect annuals or weak perennials from semidesert to desert regions of southern Africa (Smithies & Herman 2003). *Rogeria longiflora* (Royen) J.Gay ex DC. occurs in southern Namibia and up the Orange River Valley as far as Upington in South Africa, and two species in Namibia, *R. adenophylla* J.Gay ex Delile (also extends to the southern edge of the Sahara from Djibouti to Senegal and the Cape Verde Islands), and *R. bigibbosa* Engl. (Merxmüller & Schreiber 1968) on the escarpment in central Namibia. They usually grow in disturbed sites and dry watercourses. The main morphological differences between the new genus and *Rogeria* are summarized in Table 1.

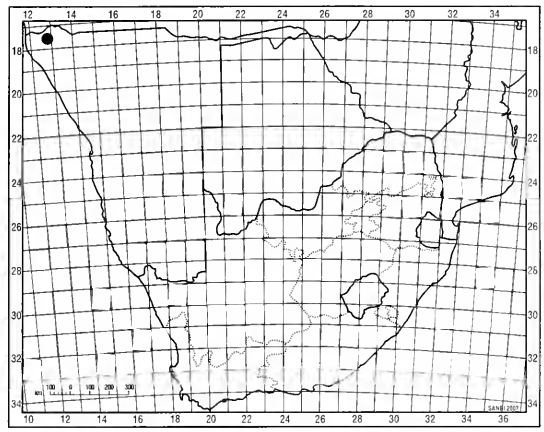

FIGURE 9.—Known distribution of *Dewinteria petrophila*.

Specimens examined

NAMIBIA.—1712 (Orokatuwo): east of Ezorotuuo, 17°23′32.0″ S 12°35′0.8″ E, (–BC), *Van Jaarsveld, Voigt & Cilliers 17520* (Wind); east of Otjihungwa, west-facing slopes of Otjihipa, (–BC), *Van Jaarsveld & Swanepoel 19413, 19527* (Wind); northwestern Kaokoveld, (–DA), *Becker & Ihlenfeldt 107560* (Wind).

TABLE 1.—Main differences between *Dewinteria* and *Rogeria*

	Dewinteria	*Rogeria*
Habit	Decumbent, no distinct main stem, amphicarpic	Distinct, erect main stem soon becoming woody, annual or biennial, not amphicarpic
Ecology	Chasmo-cremophyte	Opportunistic
Branches		
normal	Trailing, fragile	Erect, rigid
specialized	Annual, trailing, filiform, negatively phototropic, with small leaves and cleistogamous flowers	Absent
Capsules		
normal	Lanceolate in side view, slightly curved, chartaceous, 18–25 mm long	Oblong with distinct beak, lignified, bearing 2–8 emergences such as spines, tubercles or wings
specialized	Flattened, ovate to ovatecordate, 5–8 × 4.0–5.5 mm	Absent
Carpels	Nearly equal in size	Distinctly different in size
dehiscence	Loculicidal, false septa nearly completely reduced to small seams at base of capsule	Smaller adaxial carpel remains closed, bearing nearly complete false septa
Seed		
normal	Linear-oblong to club-shaped, 2.0–2.2 mm, with no distinct fringe; surface minutely foveate	Flattened, with distinct fringe; surface foveate
specialized, in cleistogamous flowers	Oblong-obovoid, 2.5–3.0 mm long, slightly flattened, minutely fringed, surface similar to normal seed	Absent

ACKNOWLEDGEMENTS

Norval Geldenhuys is thanked for the Latin translation of the diagnosis. Out thanks are due to Koos Verwey of Syncro Camp for his hospitality and help during visits to the area, to Wessel Swanepoel for assistance in the field and to Dr Gillian Maggs-Kölling of the Botanical Research Institute in Windhoek for her support of our botanical work in Namibia. Gerrit Germishuizen and Emsie du Plessis are thanked for editing the text. Ms M. Waldron of the Electron Microscope Unit, University of Cape Town, is thanked for help with the SEM micrography.

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MS. received: 2006-06-06.

DIDIEREACEAE/PORTULACACEAE

CERARIA KAOKOENSIS, A NEW SPECIES FROM NAMIBIA, WITH NOTES ON GYNODIOECY IN THE GENUS

INTRODUCTION

Traditionally, Didiereaceae *s.str.* has been treated as a family endemic to Madagascar. Based on morphological similarities, a close affinity between Didiereaceae and the African portulacaceous genera *Ceraria* H.Pearson & Stephens and *Portulacaria* Jacq. has been suggested (Rauh & Schölch 1965). Molecular evidence indicates that *Ceraria* and *Portulacaria*, as well as the African genus *Calyptrotheca* Gilg, are more closely related to Didiereaceae than to other Portulacaceae (Hershkovitz & Zimmer 1997; Applequist & Wallace 2000, 2001). The circumscription of Didiereaceae was therefore enlarged to accommodate these three genera (Applequist & Wallace 2003). Didiereaceae *s.l.* is divided into three subfamilies, of which Portulacarioideae comprises *Ceraria* and *Portulacaria*.

Ceraria is endemic to the arid western parts of southern Africa. The infrageneric classification of the group is not satisfactory and what appear to be still undescribed taxa are encountered in the wild. Herbarium specimens of the group are generally incomplete, fragmentary and not very useful for comparative morphological studies. Depending on the authority, from four (Craven 1999; Germishuizen & Meyer 2003) to six (Rowley 2002) species are recognized at present. Two of the described species, *C. carrissoana* Exell & Mendonça and *C. longipedunculata* Merxm. & Podlech, are restricted to the Kaokoveld Centre of Endemism in northwestern Namibia and southwestern Angola (Van Wyk & Smith 2001), whereas the ranges of the other species are ± centred on the Gariep Centre of Endemism in southwestern Namibia and northwestern South Africa (Van Wyk & Smith 2001; Curtis & Mannheimer 2005).

In this contribution, a new species of *Ceraria* from the Kaokoveld, Namibia, is described. Gynodioecy—a sexual state in which plants of the same species bear either functionally female or bisexual flowers—is also recorded in the genus for the first time. During a botanical expedition to the Otjihipa Mountains in northwestern Namibia, the author noticed a *Ceraria* that superficially resembles *C. fruticulosa* H.Pearson & Stephens from southern Namibia and the Northern Cape Province of South Africa. This taxon was subsequently found in several other localities in the northern Kaokoveld. It has apparently not been collected before, as no herbarium specimens of it could be found in either NBG, PRE, SAM or WIND.

Live material from the various known populations of the new species was studied in the field and from plants in cultivation. Morphological characters were all determined from mature leaves, fresh flowering material and from ripe fruit. Diagnostic features for all the above-mentioned species and *C. fruticulosa* were determined through examination of herbarium specimens and live plants in the Kaokoveld and southern Namibia (Rosh Pinah area), respectively. Additional information was found in Pearson & Stephens (1912), Exell & Mendonça (1938–1939), Merxmüller & Podlech (1961) and Podlech (1967).

Ceraria kaokoensis *Swanepoel*, sp. nov., *C. fruticulosam* H.Pearson & Stephens tangit ob arborem fruticosam et corticem brunneolam heterochromam, foliorum aliquorum laminam oblanceolatam, flores singulares vel fasciculatos, roseos. Differt cortice fissurata longitudinaliter ramis ramulisque, alba incremento recente et viridi flavo-virenteve novo incremento, prunia carente; novo incremento obtecto pilis brevibus, conicis, papilliformibus; foliis petiolatis vel subsessilibus; lamina saepe lineari-oblanceolata vel lineari, angustata, 3–4 plo longiore quam latiore, tenuiore simili longitudine, bevibus, conicis, papilliformibus pilis, viridi, prunia carente; florente profuse, ovario et ovulo parvulis.

TYPE.—Namibia, 1712 (Posto Velho): Otjihipa Mountains, 4 km ESE of Otjinhungwa, 760 m, (–AD), 17-01-2005. *Swanepoel 224* (WIND, holo.!; PRE, iso.!).

Gynodioecious, semisucculent, densely branched, shrub-like tree, 0.3–2.0 × 0.3–2.0 m. *Trunk* branching repeatedly just above ground level into many stems, rarely up to 0.2 m high, up to 0.5 m wide when wedged between rocks. *Bark* smooth, longitudinally fissured, often peeling in small flake-like pieces, dark brown, reddish brown or greyish brown, new growth green to yellowish green, bark on more recent growth creamy white, with short, brittle, conical hairs, becoming glabrous with age. *Branches and branchlets* with small, raised, cushion-like nodes, opposite and decussate at intervals of 2–13 mm; new branchlets often growing from cushions, glabrous; younger growth with short, conical, papilla-like hairs, some hairs bifid at apex; ultimate branchlets 1–2 mm diam.; when dried, irregularly winged or grooved in places when viewed under magnification, younger growth usually ± square in t/s. *Leaves* deciduous, single or clustered, opposite and decussate on new growth, green or yellow-green; lamina fleshy, flat or falcate towards abaxial side, oblanceolate, linear-oblanceolate or linear, (0.8–)3.0–12.0(–14.5) × (0.4–)1.2–3.0(–3.8) × (0.3–)0.6–1.1(–1.3) mm, ratio of length versus width 3–4:1, in t/s narrowly elliptic, crescent-shaped, reniform or oblong, adaxial side flat, convex or concave, abaxial side convex or flat, apex obtuse, acute or emarginate, often minutely apiculate, base cuneate or cuneate and abruptly rounded onto petiole, with short, conical, papilla-like hairs; margin entire; midrib or veining not visible; petiolate or subsessile, petiole up to 1 mm long, in t/s ± circular, 0.1–0.5 × 0.1–0.3 mm long, glabrous or with very short, conical, papilla-like hairs. *Inflorescence*: flowers borne on cushion-like nodes in clusters of 2–14 or solitary, usually flowers profusely. *Flowers* bisexual or female, pedicellate, glabrous, appearing before or with leaves; bracts ± ovate, flat to cucullate, up to 0.6 mm long, glabrous; pedicel very slender, 0.1–0.2 mm diam., green or reddish green, inserted on a short, peduncle-like structure, up to 0.3 mm long, involucrated by bracts; receptacle conical, green or reddish green, fleshy. *Calyx* of 2 sepals, short, broad, membranous, contiguous or distant, bract-like, persistent, hemispherical or triangular, white with pinkish tinge or pink, apical part often drying soon to conspicuous reddish brown colour. *Corolla*:

FIGURE 10.—*Ceraria kaokoensis* in its natural habitat, 1.2 m tall.

petals 5, persistent, oblanceolate, linear-oblanceolate or elliptic, often cucullate, especially towards apex, pinkish white, pink or pinkish red. *Ovary* flask-shaped, in t/s slightly flattened, triquetrous or rarely elliptic, pinkish white, pink or cherry red; style none; stigmas 3, yellowish white or white; ovule oblong-ellipsoid, up to 0.3 × 0.1 mm long. *Bisexual flowers* 1.8–2.8 mm long; pedicel 1.9–3.6 mm long; receptacle 0.3–0.4 × 0.5–0.6 mm; sepals ± 0.4 × 0.6 mm; petals 1.9–2.4 × 0.4–0.8 mm; stamens 5; anthers conspicuously pinkish red, 0.3–0.5 mm long; filaments 1.3–2.3 mm long, subterete, pinkish white or pink; pollen orange-yellow or cherry-red; pistil 0.9–1.5 mm long; ovary 0.9–1.3 × 0.3–0.4 × 0.2 mm; stigmas ± linear, pustulate above, short, up to 0.1 mm long, rarely patulous and triangular. *Female flowers* 1.1–2.0 mm long; pedicel 1.2–2.0 mm long; receptacle 0.3 × 0.6 mm; sepals ± 0.3 × 0.6 mm; petals ± 1.4 × 0.5 mm; stamens 5, rudimentary; anthers not developed; pistil 1.2–1.5 mm long; ovary 1.0–1.3 × 0.3–0.4 × 0.3 mm; stigmas linear or triangular, pustulate above, spreading, relatively long when linear, up to 0.4 mm long. *Fruit* asymmetrically elliptic or hemispherical, 3.3–4.4 × 1.4–1.8 × 0.9–1.1 mm, apiculate, almost flat, very narrowly triquetrous in t/s, soft, pink, soon drying to brown, pod-like, one-seeded, indehiscent; pedicel extremely thin, brittle; probably wind-dispersed. *Flowering time*: November to March. *Pollination*: various species of flies, blowflies and bees, including mopane bees, were observed visiting the flowers. Figures 10–12.

Diagnostic characters and affinities: *Ceraria kaokoensis* is very attractive when in flower and as such would be a valuable addition to succulent gardens. During the flowering season it is easily recognized, even from a distancê, due to the profuse pink flowers. *C. kaokoensis* is probably most closely related to *C. fruticulosa*, from which it differs mainly in bark, leaf and inflorescence characters, as well as geographical distribution. *C. kaokoensis* can also be confused with the sympatric *C. longipedunculata*, a species with which it shares a much-branched habit and narrow, superficially similar leaves. However, the leaf lamina is ± cylindrical in *C. longipedunculata*, but distinctly flattened in *C. kaokoensis*. Vegetatively *C. longipedunculata* is most similar to *C. namaquensis* (Sond.) H.Pearson & Stephens, a species from southern Namibia and adjacent parts of South Africa (Namaqualand). Some of the more prominent morphological characters to differentiate between *C. kaokoensis* and *C. fruticulosa* are summarized in Table 2.

Etymology: the specific epithet refers to the Kaokoveld of northwestern Namibia. The distribution of *Ceraria kaokoensis* falls within the previous politically demarcated Kaokoland, now part of the Kunene Region.

Distribution and habitat: *Ceraria kaokoensis* is presently known from a few isolated localities, all within

FIGURE 11.—Bark of *Ceraria kaokoensis*.

the Kaokoveld Centre of Endemism in northwestern Namibia (Figure 13). More specific localities include the Otjihipa and Hartmann Mountains to the east and west of the Marienfluss respectively; the rocky area to the south of the Engo River Valley and the mountainous area to the west and north-northwest of Sesfontein. It is localized and common to rare in these areas. The species almost certainly occurs in the adjacent mountainous parts of southwestern Angola as well, especially the Serra Cafema range, and may prove to be more widespread on the mountains of the Kaokoveld Centre of Endemism, most of which remains botanically poorly explored (Van Wyk & Smith 2001). It is found 40–110 km from the coast at altitudes of 700–1 100 m, where the mean annual rainfall is 50–150 mm (Mendelsohn *et al.* 2002). It appears to be habitat specific as it was only found in rocky places on mountain slopes, plateaus and on rocky outcrops. It is limited to the granites and gneisses of the Epupa Metamorphic Complex and to mica schist of the Damara Supergroup (Miller & Schalk 1980; Mendelsohn *et al.* 2002). At all the presently known locations, *C. kaokoensis* was found to be sympatric with *C. longipedunculata* and in some instances also with *C. carrissoana*.

Other specimens examined

NAMIBIA.—1712 (Posto Velho): Hartmann Valley Mtns, highest peak (–AC), *Swanepoel 225* (WIND), 6 km NW of Ombivango, (–AD), *Swanepoel 226* (WIND), Hartmann Valley, peak of 1 039 m high mountain, (–CA), *Swanepoel 265* (WIND), 4 km SW of Ombivango (–CB), *Swanepoel 227* (WIND); 10 km south of Engo River Valley, near Skeleton Coast Park boundary, (–CC), *Swanepoel 233* (WIND). 1813 (Opuwo): 10 km SE of Ozombari, (–DC), *Swanepoel 228* (WIND). 1913 (Sesfontein): Ganamub River, 10 km N of junction with Hoanib River, (–AB), *Swanepoel 260* (WIND), 10 km NNW of Sesfontein, (–BA), *Swanepoel 229, 231, 232* (WIND).

Key to species

1a Leaves relatively large; lamina broad, flattened, elliptic, obovate, broadly oblanceolate or suborbicular, 10–37 × 10–31 mm. Sparsely branched shrubs or small trees. Otjihipa and Baynes Mountains, Kaokoveld, Namibia; also in southwestern Angola..... *C. carrissoana*

1b Leaves relatively small; lamina narrow to broad, up to 15 × 9 mm, ± circular in t/s or flattened. Much-branched shrubs or small trees. Kaokoveld (northwestern Namibia) or Gariep Centres of Endemism (southern Namibia en adjacent parts of Northern Cape, South Africa):

2a Leaf lamina cylindrical (± circular in t/s), narrowly cuneate, conspicuously succulent. Inflorescences racemose or subpaniculate; flowers red, pink, pinkish white or white. Shrubs or small trees up to 5 m tall. Bark on stems dark- to pale-coloured: blackish brown, dark brown, reddish brown, cream-coloured or greyish white, smooth but peeling horizontally in tough, papery strips or pieces. Widespread in northern half of Kaokoveld Centre of Endemism, Namibia and in southwestern Angola..... *C. longipedunculata*

2b Leaf lamina flattened (narrowly elliptic in t/s), slightly succulent. Flowers solitary or in clusters, pink. Shrubs or shrub-like trees up to 2 m tall. Bark on stems dark-coloured. Kaokoveld and Gariep Centres of Endemism:

3a Bark on branches/branchlets longitudinally fissured, younger growth with short, conical, papilla-like hairs. Leaves with lamina narrow, ratio of length versus width 3–4:1, linear, linear-oblanceolate or oblanceolate, with short, conical, papilla-like hairs. Flowers produced in profusion, usually borne in dense clusters on cushion-like nodes along stems. Shrub-like trees up to 2 m tall. Locally in northern half of Kaokoveld Centre of Endemism, Namibia; probably also in southwestern Angola..... *C. kaokoensis*

3b Bark on branches/branchlets smooth, glabrous. Leaves with lamina narrow to broad, ratio of length versus width 1–3:1, oblanceolate, obovate, oblong-obovate or obcordate, glabrous. Flowers few, sparsely scattered along stems. Shrubs up to 1.5 m tall. Mainly Gariep Centre of Endemism, southern Namibia and Northern Cape (South Africa) ..... *C. fruticulosa*

TAXONOMIC SIGNIFICANCE OF GYNODIOECY IN *CERARIA*

The genus *Ceraria* was described by Pearson & Stephens (1912) and distinguished from *Portulacaria* in being dioecious, whereas the latter is hermaphroditic (flowers bisexual). Subsequently this sexual distinction has been widely employed in identification keys to differentiate between the two genera (Dyer 1975; Carolin 1993; Jordaan 2000; Eggli 2002). Dyer (1975), Carolin (1993), Rowley (2002) and others noted that flowers in *Ceraria* may be rarely bisexual. However, functionally unisexual flowers in *Ceraria* bear rudiments of the reciprocal organs, hence flowers may easily be mistaken for being either structurally or functionally bisexual.

As in other members of the genus, flowers of *Ceraria kaokoensis* appear structurally bisexual, although the stamens are smaller with indehiscent anthers in female flow-

TABLE 2.—Prominent differences between *Ceraria kaokoensis* and *C. fruticulosa*

Character	*C. kaokoensis*	*C. fruticulosa*
Bark texture		
on branches/branchlets	longitudinally fissured	smooth
on recent growth	creamy white	different shades of brown
on new growth	green or yellowish green, with short, conical, papilla-like hairs	reddish green or yellowish green with pale bloom, glabrous
on dried branches/branchlets	winged or grooved in places (not prominently)	prominently winged or grooved
Branchlets	in dry material, ± square in t/s	in dry material, not ± square in t/s
Leaves		
attachment	petiolate or subsessile	sessile
lamina shape	oblanceolate, linear-oblanceolate or linear; ratio of length versus width 3–4:1	oblanceolate, obovate, oblong-obovate or obcordate; ratio of length versus width 1–3:1
lamina size	0.8–14.5 × 0.4–3.8 × 0.3–1.3 mm	3.1–15.0 × 1.5–9.0 × 0.9–2.8 mm
colour	green or yellowish green	pale green, yellowish green or glaucous
indumentum	short, conical, papilla-like hair	glabrous, often with white bloom
Flowers		
inflorescence	clusters of 2–14; usually flowers profusely	clusters of 2–6; flowers few and scattered
ovary size	± 1.1 × 0.4 × 0.3 mm	± 1.5 × 0.8 × 0.5 mm
ovule size	± 0.3 × 0.1 mm	± 0.6 × 0.4 mm
Distribution	Kaokoveld Centre of Endemism, northwestern Namibia	southern Namibia and Northern Cape Province, South Africa

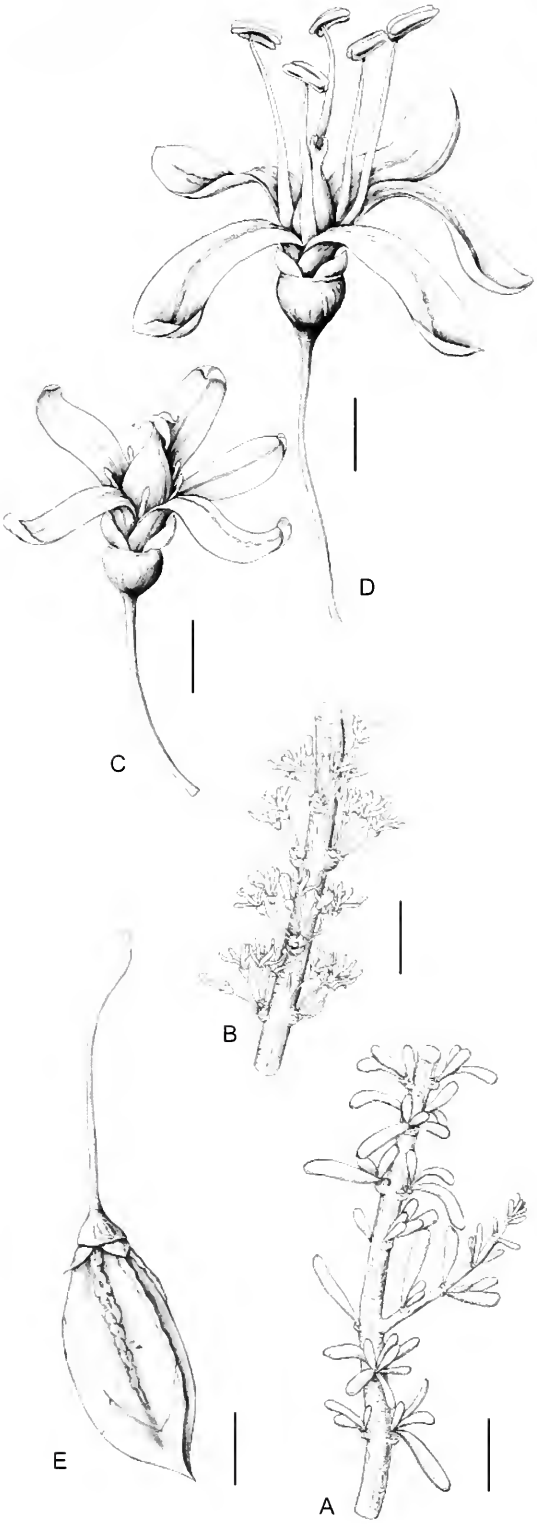

FIGURE 12.—*Ceraria kaokoensis*. A, branch with leaves; B, flowering branch; C, female flower; D, bisexual flower; E, fruit. C & E, *Swanepoel 226*; D, *Swanepoel 227*. Scale bars: A, 10 mm; B, 3 mm; C, D, 0.5 mm; E, 1 mm. Artist: Julia Kreiss.

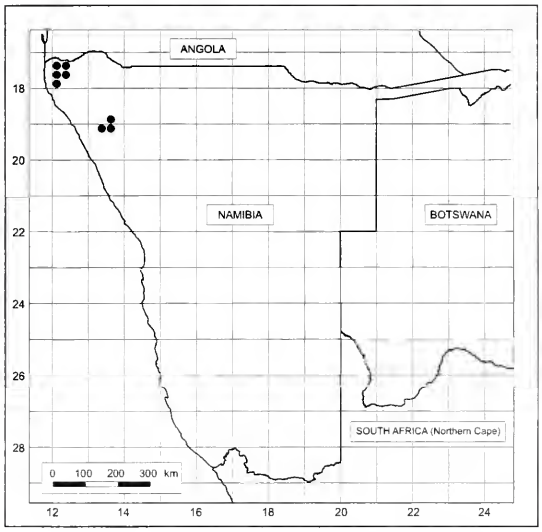

FIGURE 13.—Known distribution of *Ceraria kaokoensis*.

ers and the pistil is smaller in male flowers. However, in *C. kaokoensis* both types of flowers were seen to develop fruit with seed and the species is best described as gynodioecious. Plants of the new species are either functionally female or hermaphroditic and this is supported by observations on plants grown in the author's garden in Windhoek. However, in angiosperms, all forms of dioecy are rarely absolute (Policansky 1982). The possibility that at times some structurally bisexual flowers in *C. kaokoensis* may still be functionally male cannot be excluded.

Following the confirmation of gynodioecy in at least some plants of *Ceraria kaokoensis*, a critical re-assessment of the sexual state in other species traditionally referred to *Ceraria* is required as more members may be predominantly gynodioecious, and not dioecious (or rarely hermaphroditic) as have hitherto been reported. More field work, preferably involving long-term monitoring of specific plants, is required to fully elucidate patterns of sexual expression in the group. Moreover, observations on the sexual state of *Portulacaria armiana* Van Jaarsv. is required to confirm its current generic placement; it may well be better classified as a *Ceraria* (E.J. van Jaarsveld pers. comm.).

The presence of gynodioecy in at least one member of *Ceraria* is of considerable phylogenetic significance. Current knowledge would indicate that all other Portulacaceae are hermaphroditic, with the exception of *Talinella* Baill., a Madagascan genus (12 species) of ± woody shrubs with lax and slender branches. Most species of *Talinella* are dioecious, with either the stamens or the gynoecium vestigial. Indications are that some of the species may at least be morphologically gynodioecious (Applequist 2005). Although Hershkovitz (1993) associated *Talinella* with *Portulacaria* and *Ceraria*, subsequent molecular studies have clearly shown that it is most closely related to *Talinum* Adans. (Hershkovitz & Zimmer 1997; Applequist & Wallace 2001). Gynodioecy has, however, also been reported in the monotypic *Decaryia* Choux, one of the more basal lineages of the

otherwise dioecious Didiereaceae *s.str.* (Applequist & Wallace 2000; Schatz 2001). The presence of gynodioecy in *Decaryia* might be a plesiomorphy, an interpretation supported by its presence in the even more distantly related genus *Ceraria*. This argument presupposes reversion to hermaphrodite flowers in *Calyptrotheca*. It also provides support for the suggested placement of *Ceraria* in an expanded Didiereaceae.

ACKNOWLEDGEMENTS

I would like to thank Prof. A.E. van Wyk, University of Pretoria, for advice and support, Prof. T.V. Jacobs, UNISA, for translating the diagnosis into Latin, Ms Hester Steyn, SANBI, for preparing the distribution map and Ms Julia Kreiss for the line drawings. The curator and staff of the National Herbarium of Namibia are thanked for their assistance during visits to the herbarium. The National Herbarium of Namibia and the South African National Biodiversity Institute are also thanked for the use of information from their databases: SPMNDB, Flora DB and PRECIS. The curator, National Herbarium, Pretoria, is thanked for access to their collections; the assistance of Ms Marie Jordaan during visits to the herbarium is acknowledged with thanks. Mr Koos Verwey of Otjinhungwa is thanked for logistical support during visits to the Otjihipa Mountains. The University of Pretoria is thanked for financial support. I am especially grateful to my wife Hannelie for assistance and companionship during field trips.

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MS. received: 2006-08-11.

CRASSULACEAE

BRYOPHYLLUM PROLIFERUM NATURALIZED IN KWAZULU-NATAL, SOUTH AFRICA

The most efficient method of multiplication by succulents is via adventitious plantlet proliferation. A number of alien succulents that use this method of propagation has become naturalized or weedy in South Africa. Well-known examples include *Agave sisalana* Perrine (Smith & Mössmer 1996) and *Opuntia ficus-indica* L. (Obermeyer 1976). Abnormal (adventitious) development is reflected in the panicle of *A. sisalana* becoming bulbiferous after flowering, and shooting and rooting of the detached fruits occurring in *O. ficus-indica*. Amongst the few Crassulaceae that have been recorded naturalized in southern tropical Africa, the genus *Bryophyllum* Salisb. features prominently (Fernandes 1983). However, in the *Flora of southern Africa* region, *Bryophyllum delagoense* (Eckl. & Zeyh.) Schinz is the only member of this family to have been recorded as such (Toelken 1985; Dreyer &

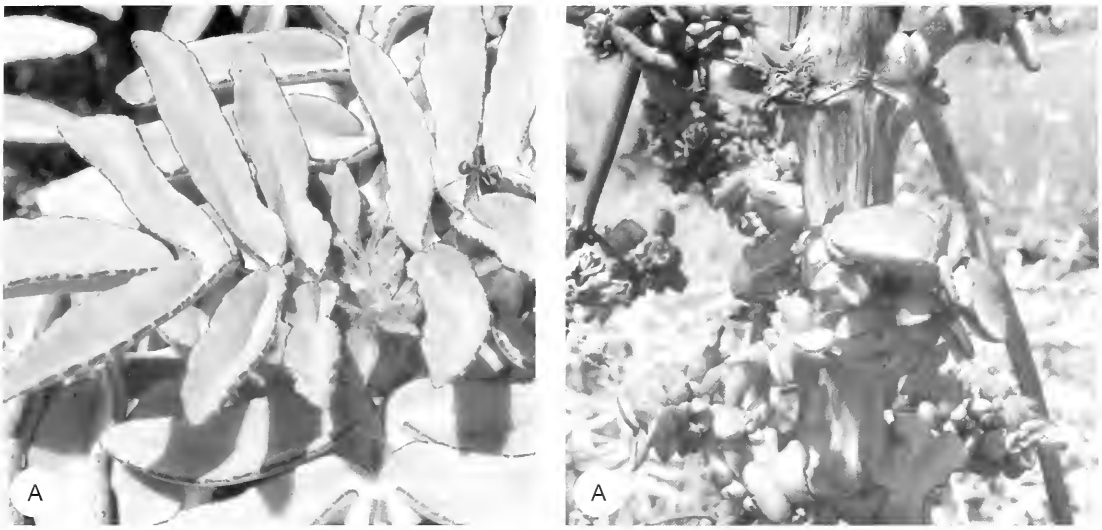

FIGURE 14.—A, leaves; B, plant showing adventitious buds.

Makwarela 2000) although Wells *et al.* (1986) listed *B. proliferum* Bowie ex Hook. as a potential problem plant.

Recent field work in KwaZulu-Natal and subsequent consideration of herbarium collections have revealed that the hardy stem and leaf succulent *Bryophyllum proliferum* has escaped from cultivation. Although these populations have not been shown to be self replacing for a period of ten years, we categorize this hardy invasive as naturalized, for the Botha's Hill population is evidently expanding through recruitment. The population status at the original 1985 collection site on Ismont Farm has not been reassessed. Significantly, in defining 'naturalized' alien invasive taxa, Pyšek *et al.* (2004) admitted that how long a species must persist to be considered naturalized is inevitably arbitrary.

This tall species, a native of Madagascar, is grown predominantly for its foliage (Figure 14) rather than its rather unattractive greenish yellow flowers; detracting further from its horticultural appeal are the inflorescences (terminal panicles) that are usually disfigured by the numerous adventitious buds that spring from the pedicel bases of aborted flowers. Plants grow as clump-forming subshrubs, with decussate leaf pairs borne along the upper third of the four-angled, somewhat woody stems. The impari-pinnatisect leaves are a verdant pale green and marginally crenate, each with 3–7 opposite pairs of sessile leaflets that are subdecurrent and asymmetric at the base. Small plantlets may additionally be produced in the crenatures of the entire leaf, and along the upper grooved midrib. Wells *et al.* (1986) described further proliferation via root suckers. The leaves are borne more or less horizontally, effectively shading out low-growing indigenous vegetation.

It is likely that the species has been naturalized (Figure 15) for some time but has gone unnoticed. This phenologically plastic species presents variable leaf morphologies and coloration; for example, leaf margins turn red under high light intensities, whereas this trait is absent from specimens established in shade.

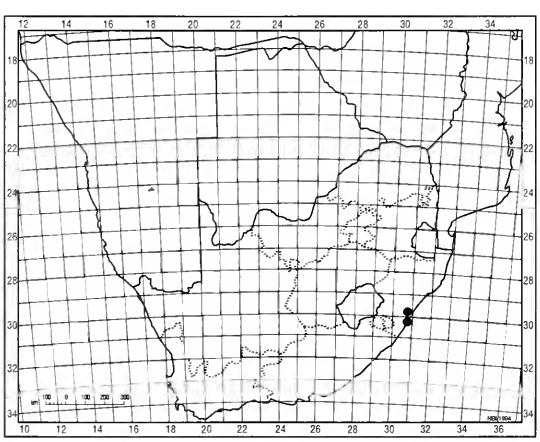

FIGURE 15.—Known distribution of *Bryophyllum proliferum* based on specimens at NH, NU and PRE.

Specimens examined

KWAZULU-NATAL.—2930 (Pietermaritzburg): 1.5 km east of The Valley Trust, Portion 585 of the Farm Assagay Kraal, Botha's Hill, colony alongside stream in granite gully. Growing in semi-shade along with *Adiantum capillus-veneris* and *Pteris vittata*, 450 m, S 29°,735169; E 30°,748894, (–DA), 05-05-2007, *N. Crouch 1123* (NH). 3030 (Port Shepstone): edge of grassy track in *Eucalyptus* plantations between Mount Langford and Loni River (mid-Illovo area), on Ismont Farm, (–BA), 15-07-1985, *B. Culcross s.n.* (NH).

ACKNOWLEDGEMENTS

Ms L. Henderson and Mr G. Nichols are thanked for helpful discussions on the identity of *B. proliferum*.

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CRASSULACEAE

CRASSULA STREYI RECORDED FROM THE EASTERN CAPE, SOUTH AFRICA

The most recent checklist of the Crassulaceae in South Africa (Burgoyne 2006) delimits, as have earlier accounts (Hunt 1979; Dreyer 1993; Burgoyne 2003), *Crassula streyi* Toelken as a KwaZulu-Natal endemic. However, recent field work in the Transkei region of the Eastern Cape Province and subsequent consideration of herbarium materials has revealed that this species has been known from the Eastern Cape for over 20 years. It was first collected there by Mr Tony Abbott in 1985, in forest adjacent to the Msikaba River Mouth, near where the Sao Bento was wrecked in 1554. It has more recently been collected to the north of the Mkambati Game Reserve, alongside the Mtentu River (Figure 16). It was considered a highly restricted endemic, occurring at a few localities within the Mtamvuna Nature Reserve (Toelken 1973, 1985); its range now extends southwestwards by approximately 25 km. This species evidently occurs in suitable rocky forest habitat in the intervening Mzamba Gorge system, and will likely be found along the lower Mnyameni Gorge. The Eastern Cape collections confirm *C. streyi* sight records, and its status as endemic to the Msikaba sandstone-defined Pondoland Centre (Scott-Shaw 1999; Van Wyk & Smith 2001; Abbott 2006). Furthermore, the Izotsha Falls (within 5 km of Oribi Gorge) voucher extends its range northeastwards by 40 km. It is restricted to altitudes ranging from 2–280 m and is therefore always found close to the coast.

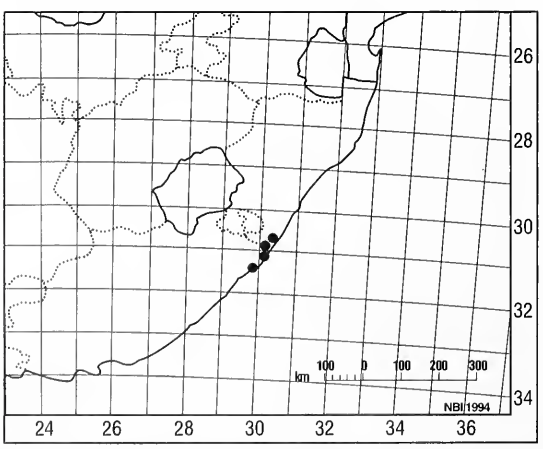

FIGURE 16.—Known distribution of *Crassula streyi* based on specimens at GRA, KEI, NH, NU and PRE.

Previously uncited KwaZulu-Natal vouchers extend substantially the documented phenology of *C. streyi* (Toelken 1985): plants flower from spring to late summer as well as in mid-winter.

Specimens examined

KWAZULU-NATAL.—3030 (Port Shepstone): Izotsha Falls view site, ex hort., (–CB), 25-03-1974, *Hilliard 5493* (NU); Umtamvuna Nature Reserve, forest walk, rock face in forest, (–CC), 24-12-1983, *A. Abbott 1586* (NH). 3130 (Port Edward): Umtamvuna Nature Reserve. Clearwater River Trail, (–AA), 04-02-1983, *A. Abbott 766* (NH); Umtamvuna Nature Reserve, (–AA), 08-03-2001, *P.M. Gavhi, P.J.H. Hurter & E. Van Wyk 61* (PRE).

EASTERN CAPE.—3129 (Port St Johns): Mkambati, Sao Bento crossing, rock in forest, (–BD), 24-03-1985, *A. Abbott 2553* (KEI; NH). 3130 (Port Edward): Ikubu River Gorge, tributary of the Mzamba River, riverine forest in shade on forest floor, (–AA), 22-06-1986, *A.E. van Wyk 7305* (KEI); Transkei, Mzamba District, Sikuba River, in forest, (–AA), 22-06-1986, *A. Abbott 3176* (KEI); rocky ledge alongside northern bank of Mtentu River, 1 km inland from mouth, opposite Mkambati Game Reserve, ex hort., (–AA), 10-06-2007, *N. Crouch, T. Edwards & D. Bellstedt 1129* (NH); Mkambati Reserve, Kebengeni River (tributary of Mtentu River), riverine scrub, growing on a rock on sandy soil on streambank, in sun on a level area, undisturbed, Msikaba formation sandstone, (–AA), 15-09-1998, *E. Cloete 5236* (GRA); common in cliffs of estuary of Mtentu River, (–AA), 06-2006, *Edwards, Crouch & Bellstedt 3275* (NU).

ACKNOWLEDGEMENTS

The trip during which the most recent material was obtained, was financed by the University of KwaZulu-Natal, with D. Bellstedt kindly assisting with transport in the field. Mr A. Dold of GRA and Dr K. Immelman of KEI are thanked for making their specimen data available.

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Bothalia 37,2: 211–214 (2007)

Stem diameter and bark surface area of the fluted trunk of *Balanites maughamii* (Balanitaceae)

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Keywords: *Balanites maughamii* Sprague, commercial bark harvesting, diameter at breast height (dbh), traditional medicine

ABSTRACT

Balanites maughamii Sprague (Balanitaceae) is a woodland tree used and harvested for bark products in the traditional medicine trade of South Africa. The tree has a distinctively fluted and buttressed stem, especially in mature individuals. This short communication quantifies the relationship between two diameter measurements D1 and D2 that respectively exclude and include the bark surface contained in the convolutions of the flutes at five height intervals up the stem to 2 m. Regressions show D1 to be an accurate predictor of D2 ($r^2 = 0.97–0.99$) over a range of tree sizes, hence obviating the necessity to measure both D1 and D2. The circumference and bark surface area on the stem was determined to estimate the quantity of bark that can potentially be harvested. At least 69% of the stem circumference and bark surface area was estimated to be contained within the convolutions of the flutes.

INTRODUCTION

Balanites maughamii Sprague (Balanitaceae) is a medium to large, slow-growing deciduous tree ranging from 8–20 m tall (Pooley 1993). The stem is straight and the trunks of older trees are distinctively fluted and buttressed (Pooley 1993; Van Wyk & Van Wyk 1997). The grey bark has medicinal value and is harvested and sold to consumers in traditional medicine markets in KwaZulu-Natal (KZN), Gauteng and Mpumalanga (Botha *et al.* 2001; Grace 2002; Williams 2003) (Figure 1). Based on the total amount of bark harvested (m^2), *B. maughamii* was ranked third out of 36 tree species harvested for bark in the woodlands of southern Maputaland, KZN (Twine 2004). A detailed population study there revealed that 55% of all individuals [diameter at breast height (dbh) > 10 cm] had harvest wounds, and the mean amount of bark harvested per individual was 1.09 m^2 (Twine 2004).

In KZN, the species is classed as declining and considered to be heavily exploited for bark products (Cunningham 1988; Netshiluvhi 1999; Grace 2002). Its legal status in KZN is described as 'controlled' by Von Ahlefeldt *et al.* (2003), i.e. written permission is required from the land owner/holder for this species to be harvested or collected from the wild. The turnover from 23 traders in the Isipingo and Victoria Street informal herbal medicine markets in Durban was estimated to be 187 fifty kg bags per annum (± 1995) (Netshiluvhi 1999). On the Witwatersrand, 56% of the *muti* shops sold the bark (Williams *et al.* 2001), and a volume equivalent to ≈ seven 50 kg bags were present between 17 of the 100 traders surveyed in the Faraday Street traditional medicine market in Johannesburg in January 2001 (Williams 2003). On the western boundary of the Kruger National Park, 29% of the vendors sold *Balanites maughamii* bark and considered it a readily available resource (Botha *et al.* 2001). The mean price per 50 kg bag of *B. maughamii* bark bought by *muti* shops in Johannesburg in 1995 was R66.70 ± R33.50 [± standard deviation (SD)] (n = 15), and in 2001 a bag cost ≈ R100.

As part of an extensive investigation into the relationship between tree size and bark thickness of six tree species, including *Balanites maughamii*: 1, to determine the size of trees targeted by commercial bark harvest-

FIGURE 1.—*Balanites maughamii* individual repeatedly harvested for bark on communal land in the Ingwavuma region of KwaZulu-Natal in 1998. Parts of stem, including buttresses have been removed.

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ers from the thickness of the bark sold in the *muti* markets; 2, the mean wet and oven-dry bark thickness per tree size class; and 3, the mean harvestable bark mass per stem (Williams *et al.* 2005, in press a, b), various aspects of the tree stem profile were measured. These aspects included: 1, approximate height of the tree and branch-free bole length; and 2, diameter of the stem at five height intervals. Bark thickness was also measured. Data collected for *B. maughamii* are a subset of the original study. This short communication describes specific aspects of the *B. maughamii* tree stem profile related to the fluted trunk, including: 1, the relationship between two measurements around the stem that respectively include and exclude the bark surface area contained in the convolutions of the flutes; 2, the number of flutes observed at 1.3 m above ground (where dbh is normally measured); and 3, the percentage of the stem enclosed within the flutes.

METHODS

Between March and May 1998, 39 *Balanites maughamii* stems were measured at six sites in three South African provinces (Table 1). At each sample site, a population of trees was located and individuals were selected from five stem diameter classes based on diameter at breast height (dbh) ranging between 10 cm and 60 cm. A minimum of five and a maximum of ten trees were measured per diameter class (not per site). None of the individuals had suffered any prior harvesting damage, and the bark on the bole was intact. *Balanites* individuals larger than 60 cm dbh were found in communal lands; however, these trees were not sampled as bark harvesters had previously removed whole sections of the bark, fluted stems and buttresses. The method used for assessing vertical height was a direct estimate using a 2 m height pole, with 0.5 m intervals. The number of pole lengths was counted by eye to estimate tree height and branch-free bole length. After the 22 *Balanites* stems were measured, the number of flutes at dbh were counted and their depth was categorized (subjectively, shallow or deep).

It is standard practise in forestry to measure tree stem girth with a forestry diameter tape. The tape is calibrated in π centimetres so that a circumference measurement is converted directly to a diameter measurement (Philip 1983), and the measurement is thus recorded as a diameter dimension rather than a circumference. Two diameter readings were taken at five height intervals (0.5 m, 1.0 m, 1.3 m, 1.5 m and 2.0 m, abbreviated as $D_{0.5}$, $D_{1.0}$, $D_{1.3}$, $D_{1.5}$ and $D_{2.0}$ respectively) from the *Balanites maughamii* stem: 1, a circumference measurement around the stem that excludes the area inside the flutes (diameter 1, D1); and 2, a circumference measurement into the convolutions of the flutes, measuring along the entire bark surface (diameter 2, D2) (Figure 2). Hence D1 is the typical stem diameter measurement taken by foresters, usually at breast height (1.3 m, dbh), whereas D2 is a hypothetical diameter, where the flutes are pushed out to form a circle. Initially, only D1 was measured, but after six samples, D2 was also measured.

TABLE 1.—Sample sites and no. individuals sampled per site

Province	Area in the province	Ownership and management regime	*n*
Limpopo	Western Soutpansberg	Private farm 1 (south of Wyllie's Poort)	17
Limpopo	Western Soutpansberg	Private farm 2 (north of Wyllie's Poort)	13
Mpumalanga	Nelspruit	Protected area	2
KwaZulu-Natal	Ingwavuma	Communal land	3
KwaZulu-Natal	Zululand	Protected area	1
KwaZulu-Natal	Zululand	Private protected area	3

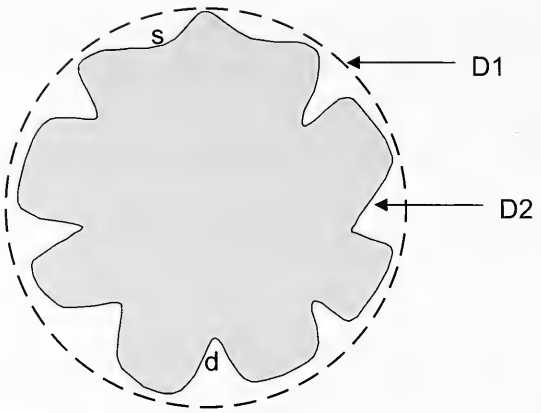

FIGURE 2.—Schematic representation of a cross section through *Balanites maughamii* tree stem showing measurements D1 and D2. D1: measurement around stem that excludes bark surface in flutes; D2: measurement in concave convolutions of flutes, thereby measuring entire bark surface. Measurements were made using a forestry diameter tape, calibrated in π centimetres, which converts a circumference measurement of a stem directly into a 'diameter' measurement. Measurements of D1 at 1.3 m above ground (dbh) were used to construct stem diameter classes. s, subjective classification of shallow flutes; d, deep flutes.

RESULTS AND DISCUSSION

The *Balanites maughamii* individuals measured, ranged in height from 4 to 12 m, with a mean of 8 ± 2 m (SD). Branch-free bole length was 2.9 ± 1.4 m (SD). The dbh of the largest tree sampled was $D1_{1.3}$ = 59.2 cm and $D2_{1.3}$ = 260.0 cm (circumference equals 186 cm and 817 cm respectively), from a site in a private protected area in KZN.

There was a very strong positive relationship between D1 and D2 at all height intervals up the stem (Figure 3A–E), especially at $D_{0.5}$ ($r^2 = 0.988$, $p < 0.0001$, Figure 3A). No branching occurred on the stem below 0.9 m, hence results for $D_{0.5}$ were not affected by the response of the tree to branching. The quadratic regressions were only slightly better fits than the linear regressions (results not shown). For example, $r^2 = 0.988$ for the quadratic equation at $D_{0.5}$, whereas $r^2 = 0.979$ for the linear equation at the same height.

These results show that by measuring D1 at a particular stem height, D2 can be accurately estimated, hence obviating the necessity to measure both D1 and D2. When compared with the *observed* D2, the D2 *predicted* by the quadratic regression equations was slightly

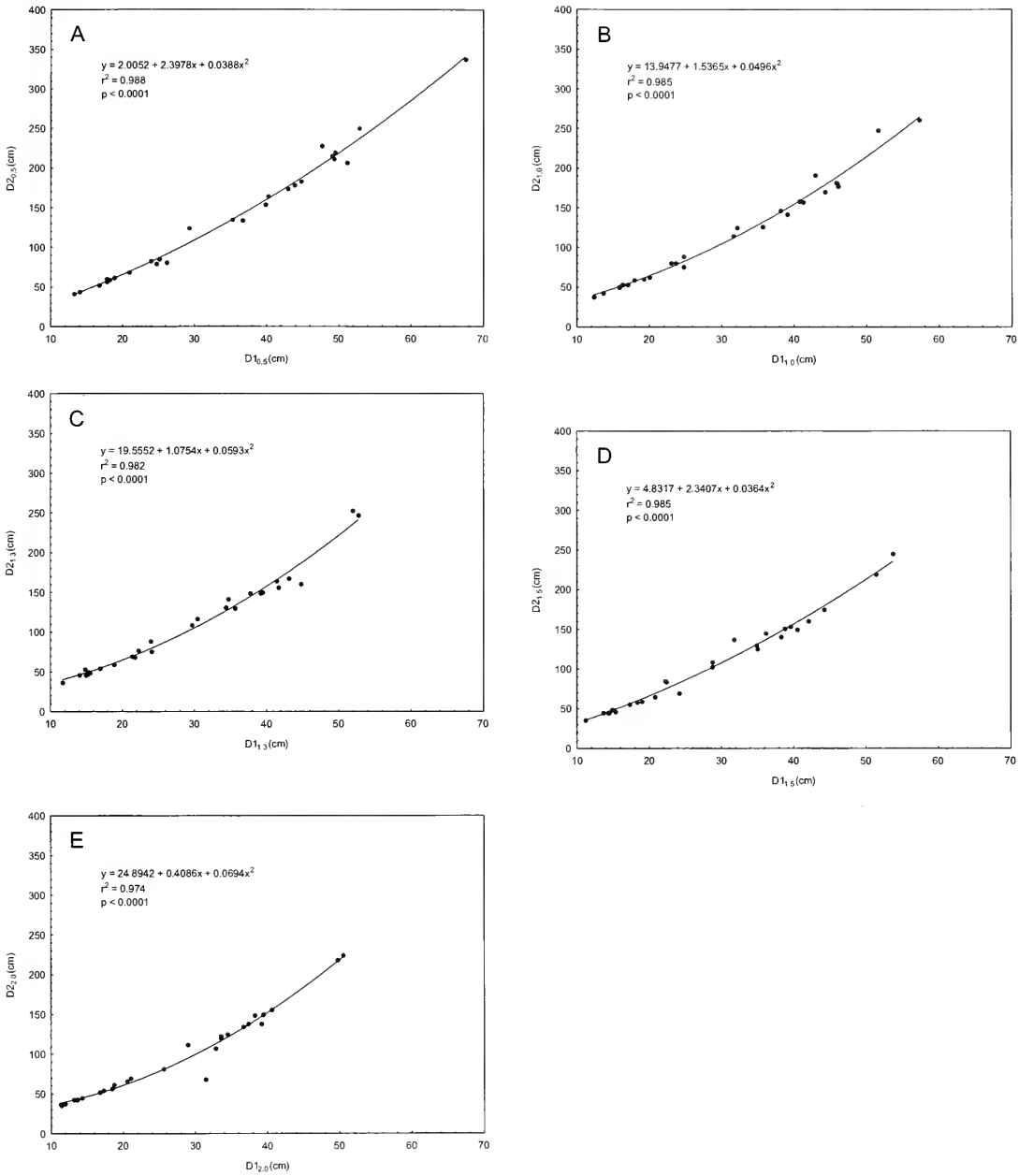

FIGURE 3.—Relationship between stem diameter 1 (D1) and stem diameter 2 (D2) measured at A, 0.5 m; B, 1.0 m; C, 1.3 m; D, 1.5 m; and E, 2.0 m above ground [n = 28 (all graphs)]. To obtain circumference, multiply D1 or D2 by π.

overestimated [mean percentage error = 0.35 ± 5.99% (SD), n = 154]. By contrast, the linear regression equations tended to underestimate the predicted D2 [–1.22 ± 9.04% (SD), n = 154].

By converting the observed D2 measurements back to circumferences, the area of bark (m^2) on the stem could be estimated. The mean amount of bark up to 2 m on the stem ranged from 3.3 ± 0.6 m^2 (SD) (n = 10) on trees in the 10–19 cm diameter class (D1), to 16.1 ± 0.7 m^2 (SD) (n = 4) on trees in the 50–59 cm diameter class (Table 2).

As the dbh of *Balanites maughamii* individuals increased, the number and depth of flutes at $D_{1.3}$ was observed to increase (Table 3), thus increasing the proportion of the bark surface area within the convolutions of the flutes. Trees in the 10–20 cm and 20–30 cm stem diameter classes (D1) generally had two shallow flutes and one deep one. As tree size increased, the shallow flutes became deeper until there were 2 or 3 and 4 or 5 deep flutes in the 30–40 cm and 40–50 cm classes respectively. Trees larger than 50 cm had more than six deep flutes with sometimes as many as 10 per stem as the trees approached 60 cm dbh.

TABLE 2.—Estimated mean bark area (m^2) up to 2 m height per stem size class

Size-class (dbh, cm) (D1)	Mean estimated bark area (m^2)	SD	Min.	Max.	n
10–20	3.29	0.60	2.38	4.24	10
20–30	5.13	0.80	4.04	6.84	8
30–40	9.16	1.01	7.62	10.51	7
40–50	10.98	0.22	10.83	11.31	4
50–60	16.11	0.79	15.15	16.67	4

dbh, diameter at breast height; SD, standard deviation.

Most of the trunk circumference is contained within the concave sections of the flutes (Figure 4). At 0.5 m above ground, 73.0 ± 4.0% (SD) of the stem was within the flutes. The percentage decreased gradually with increasing height up the stem until it was 70.3 ± 4.3% (SD) at 2 m (Figure 4). Furthermore, in trees with larger dbh, a greater percentage of stem was enclosed within the flutes. Similarly, more than two thirds of the bark surface area is within the flutes [mean = 72 ± 3% (SD), n = 31]. The proportion of the bark inside the flutes varied according to tree size, with up to 79% of the bark area found in the flutes of trees in the 50–59 cm stem diameter class (D1), and decreasing to 69% in flutes of trees in the 10–19 cm stem diameter class.

CONCLUSION

Despite the buttresses in the *Balanites maughamii* stems, it appears that the diameter measurement D1 is an acceptable predictor of D2. Hence, the bark surface area can be estimated as well as the amount of bark that can potentially be removed from the stems. Because most of the bark area is contained within the convolutions of the flutes, the tree trunks are difficult to ring-bark. Even when harvesters remove whole sections of the flutes/buttresses, including the timber, they usually leave behind some of the bark at the base of the flute. This may potentially enable wound recovery following harvesting and probably makes the species more resilient to harvesting.

ACKNOWLEDGEMENTS

Thanks are due to Megan Whelan for her field assistance; the Eddie Young Memorial Bursary of the Endangered Wildlife Trust and the National Research Foundation for funding.

TABLE 3.—Observed number and depth of flutes per measured tree at $D_{1.3}$ (dbh). Individual trees are enclosed in parentheses in column three

Size-class (dbh, cm) (D1)	No. trees measured (n = 15, out of 39)	Observed number and depth of flutes per tree at $D_{1.3}$ (dbh)
10–20	1	(1d, 2s)
20–30	4	(1s); (1d, 2s); (1d, 2s); (1d, 3s)
30–40	6	(2d); (3d); (3d); (3d); (3d, 1s); (4d)*
40–50	2	(4d); (5d)
50–60	2	(6d); (10d)

* dbh (diameter at breast height) of individual tree = 39.4 cm; s, no. of shallow flutes; d, no. of deep flutes (subjective descriptions of flute depth).

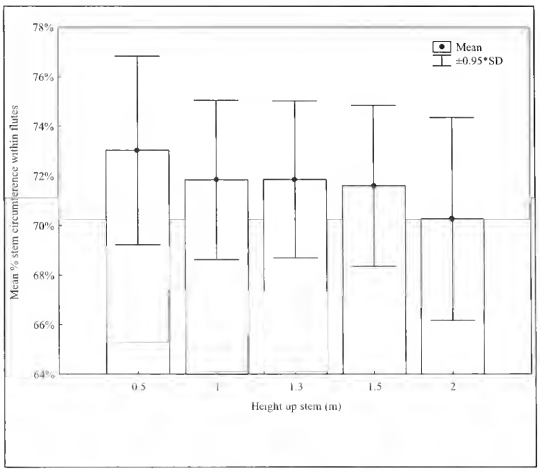

FIGURE 4.—Mean percentage of stem circumference contained within concave sections of flutes at five height intervals up stem to 2 m, including diameter at breast height (dbh, 1.3 m). Means calculated for trees ranging from 11.7 cm to 52.7 cm dbh. SD, standard deviation.

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Bothalia 37,2: 215–248 (2007)

Invasive, naturalized and casual alien plants in southern Africa: a summary based on the Southern African Plant Invaders Atlas (SAPIA)

L. HENDERSON*

Keywords: biomes, casual alien plants, invasive plants, Lesotho, naturalized plants, roadside surveys, SAPIA mapping project, South Africa, Swaziland

ABSTRACT

The primary objective of this publication is to provide an overview of the species identity, invasion status, geographical extent, and abundance of alien plants in South Africa, Swaziland and Lesotho, based on field records from 1979 to the end of 2000. The dataset is all the species records for the study area in the Southern African Plant Invaders Atlas (SAPIA) database during this time period. A total of 548 naturalized and casual alien plant species were catalogued and invasion was recorded almost throughout the study area. Most invasion, in terms of both species numbers and total species abundance, was recorded along the southern, southwestern and eastern coastal belts and in the adjacent interior. This area includes the whole of the Fynbos and Forest Biomes, and the moister eastern parts of the Grassland and Savanna Biomes. This study reinforces previous studies that the Fynbos Biome is the most extensively invaded vegetation type in South Africa but it also shows that parts of Savanna and Grassland are as heavily invaded as parts of the Fynbos. The Fabaceae is prominent in all biomes and *Acacia* with 17 listed species, accounts for a very large proportion of all invasion. *Acacia mearnsii* was by far the most prominent invasive species in the study area, followed by *A. saligna*, *Lantana camara*, *A. cyclops*, *Opuntia ficus-indica*, *Solanum mauritianum*, *Populus alba*/×*canescens*, *Melia azedarach*, *A. dealbata* and species of *Prosopis*.

INTRODUCTION

History of roadside surveys in South Africa

Roadside surveys of invasive plants in South Africa were pioneered by Henderson and Musil (née Duggan) starting in 1979 in the central Transvaal, now Gauteng (Wells, Duggan & Henderson 1980), with the remainder of the Transvaal surveyed in 1982 and 1983 (Henderson & Musil 1984). Surveys of the rest of South Africa were conducted by Henderson from 1986, starting with Natal (Henderson 1989), followed by the Orange Free State (Henderson 1991a), northern Cape (Henderson 1991b), eastern Cape (Henderson 1992), western and central Cape (completed in 1993 but unpublished), and southern and southwestern Cape (Henderson 1998a).

All terminology used in this paper relating to invasive plants such as 'alien', 'invasive', 'naturalized', 'casual alien', 'weed' and 'environmental weed' conforms, as far as possible, to the definitions provided by Richardson *et al.* (2000) and Pyšek *et al.* (2004). The method used in these surveys was designed initially to make use of otherwise unproductive travelling time whilst engaged in other research projects. The method was refined as the surveys progressed until a standardized method was developed (see Henderson 1992, 1998a). The presence and abundance of all alien trees, large shrubs and conspicuous climbers which appeared to be naturalized or occurring outside of cultivation were recorded for each veld type category, habitat type (roadsides and adjoining veld, and streambanks) and quarter-degree/fifteen minute square traversed by road.

Recordings of species on roadsides and in the adjacent veld were made from a moving vehicle along road transects of between five and 10 km long. Recordings of streambank species were made at virtually all watercourse crossings on the survey route.

The Southern African Plant Invaders Atlas mapping project (SAPIA)

The Southern African Plant Invaders Atlas (SAPIA) is a mapping project, launched in January 1994, to collate information on the distribution, abundance and habitat types of invasive and naturalized alien plants in southern Africa (Henderson 1998b). The first phase of SAPIA, involving volunteer participants, was scheduled for a five-year period, ending in December 1998. The atlas region covered South Africa, Lesotho and Swaziland. Information was recorded on two standardized atlas sheets, with slightly different species lists, covering the western and eastern halves of the atlas region. One hundred plant taxa were listed on each sheet, with a combined total of 161 species. A pocket field guide was compiled to help with the identification of all listed species (Henderson 1995).

SAPIA database

A computerized SAPIA database was created by incorporating all Henderson survey data (± 23 000 records) and SAPIA phase one project data (± 20 000 records). The SAPIA project continued on an ad hoc basis and by the end of 2000 a total of ± 48 000 records had been accumulated. Thereafter, the SAPIA initiative dwindled due to lack of funding. Only 10 000 records were added in the five year period from 2001 to the end of 2005. The SAPIA project was revived in 2006 with funding from the Department of Water Affairs and Forestry's Working for Water Programme. The SAPIA database has been computerized using Microsoft Access and is housed at the Plant Protection Research Institute in Pretoria.

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Objectives of this study

- To provide an overview of the species identity, invasion status, geographical extent, and abundance of alien plants in South Africa, Swaziland and Lesotho, based on field records from 1979 to the end of 2000.
- To highlight the most prominent invaders in the region as a whole, in each of the biomes, and in riparian and wetland habitats.
- To compare invasion and provide species profiles for each of the biomes.

METHODS

Sampling method

The dataset for this study is all the species records for South Africa, Swaziland and Lesotho in the SAPIA database collected from 1979 until the end of 2000 (± 48 000 records). During this period a concerted effort was made to gather as much data from as wide an area as possible. The information gathered is the best available data concerning the extent of invasion and species composition, at least of the larger trees, shrubs and conspicuous climbers, in the study area over this time period.

The SAPIA dataset was subdivided on a quarter-degree square (QDS) basis into six datasets representing the biomes of southern Africa. According to Rutherford (1997) there are seven biomes in southern Africa: Savanna, Fynbos, Forest, Grassland, Nama-Karoo, Succulent Karoo and Desert. The Forest Biome in southern Africa is miniscule, only occurring in the Knysna area. However, if all the forest patches elsewhere are included, its area increases several-fold (Rutherford 1997). In this study Forest refers to the Forest Biome and also forest habitats within the Savanna, Fynbos and Grassland Biomes. The Desert Biome occurs almost exclusively in Namibia, except for a very small patch along the Orange River bordering on South Africa that has been excluded from this study.

Data treatment

Abundance

Species abundance ratings in the SAPIA database are qualitative estimates. Table 1 shows the abundance ratings used in the SAPIA database and the equivalent rating used in Henderson surveys. For the purposes of this study, species abundance ratings were converted to a numerical value as done in previous surveys (Henderson 1998a) and each abundance rating was expressed in numbers of individuals or groups per 10 km transect/recording (Table 1).

Prominence

A similar formula was used in this study to calculate prominence as in previous studies by Henderson (1998a). The prominence value of a species x in category y (biome or study area) was calculated as follows:

$$\text{prominence value} = \frac{\text{total abundance of species x in category y}}{\text{sum of the abundances of all species in category y}} \times 100 + \frac{\text{total species records of species x in category y}}{\text{sum of the records of all species in category y}} \times 100$$

The highest prominence values in a given category which add up to ± 160 points out of a total of 200 are printed in bold in Appendices 1–3. The cut-off point is arbitrary but represents the upper 80% of the summed prominence values.

RESULTS

A total of 548 naturalized and casual alien plant species were catalogued in the SAPIA database for South Africa, Swaziland and Lesotho from 1979 to the end of 2000 (Appendix 4). At least 119, mainly herbaceous, taxa are considered to have been under-recorded and

TABLE 1.—Abundance ratings used in Henderson surveys, SAPIA and this study

Henderson surveys					SAPIA	This study
Rating	Roadsides and veld	No.*	Streambanks	Rating	All habitats†	All habitats#
9	A virtually continuous, almost pure stand	1 000+	Any number, with cover more than 75% of the reference area	7	Very abundant	1 000
8	The commonest species in a generally continuous tree or shrub layer	500–999	Any number, with 50–75% cover	6	Very abundant	1 000
7	Less abundant than above but > 20 individuals or groups per km	200–499	Any number, with 25–50% cover	5	Abundant	200
6	10–20 individuals or groups per km	100–199	Any number with 5–25% cover	4	Abundant	200
5	5–10 individuals or groups per km	50–99	Numerous, but < 5% cover or scattered, with cover up to 5%	3	Frequent	50
4	2–5 individuals or groups per km	20–49	Few, with small cover	2	Frequent	50
3	± 1 individual or group per km	5–19	Solitary, with small cover	1	Occasional	10
2	Less abundant than above but more than 1 individual or group per 5 km	2–4			Occasional	10
1	± 1 plant or group per 5–10 km	1			Rare	1

*, approximate numbers of individuals or groups per 10 km transect.
†, very abundant extensive stands; abundant; many clumps or stands: frequent, many sightings of single plants or small groups: occasional, a few sightings of one or a few plants: rare, one sighting of one or a few plants.
#, weighted abundance, numbers of individuals or groups per 10 km transect/recording.

the results presented are not a true reflection of their status (see asterisked species in Appendix 4). A further 45 species were recorded in the study area after 2000 and are asterisked in the species checklist (Appendix 5). A total of 601 species are listed in the full checklist given in Appendix 5—this is estimated to be about half the total number of naturalized and casual alien plant species in southern Africa. The most comprehensive listing of naturalized species in southern Africa, compiled by Wells *et al.* (1986), contains approximately 965 species, predominantly herbaceous. The SAPIA database, with a bias towards trees and shrubs, has an additional 231 species not listed by Wells *et al.* (1986).

Geographical extent of invasion

Alien plant invasion was recorded almost throughout the study area. Figure 1A shows invasion in terms of species numbers per QDS and Figure 1B shows the severity of invasion per QDS based on the total weighted abundance of all species per QDS. Most invasion, in terms of both species numbers and total species abundance, was recorded along the southern, southwestern and eastern coastal belts and in the adjacent interior. This corresponds with the regions of highest rainfall (Schulze 1997), urban development, and cultivation of agricultural and silvicultural crops. It also includes the whole of the Fynbos and Forest, and the moister eastern parts of the Grassland and Savanna Biomes (Figure 1C). Distribution maps of 234 species, which include all declared species under the Conservation of Agricultural Resources Act, Act 43 of 1983, and amended in 2001, are given in the field guide *Alien weeds and invasive plants* (Henderson 2001).

Prominent invasive species

There were 97 prominent invasive species in the study area and each of the biomes (Appendices 1–3). All these species were invading natural and semi-natural habitats.

Study area

Fifty species account for most invasion (the upper 80% of the summed prominence values) in the study area (Appendix 1). *Acacia mearnsii* (black wattle) was the most prominent species by far, with a value of 18.37 (out of a maximum of 200) which is more than double the value of the second-ranked species, *A. saligna* (Port Jackson). The remaining top ten most prominent invaders in the study area were in order, *Lantana camara* (lantana), *A. cyclops* (rooikrans), *Opuntia ficus-indica* (sweet prickly-pear), *Solanum mauritianum* (bugweed), *Populus alba/×canescens* (white/grey poplars—values of these two taxa were combined where they were difficult to distinguish at a distance during roadside surveys), *Melia azedarach* (seringa), *A. dealbata* (silver wattle) and *Prosopis* spp. (*P. glandulosa* var. *torreyana, P. velutina* and their hybrids)(mesquite trees). Together these species cover almost the entire study area (Figures 2, 3).

Savanna Biome

Forty-eight species were the most prominent invaders in the Savanna Biome (Appendix 2). *Lantana camara* was the most prominent species with a prominence value of 20.6, followed by *Chromolaena odorata* (triffid weed) with a value of 14.2 and *Melia azedarach* with a value of 12. The remaining top ten invaders were, in order, *Solanum mauritianum*, *Acacia mearnsii*, *Opuntia ficus-indica*, *Ricinus communis* (castor-oil plant), *Psidium*

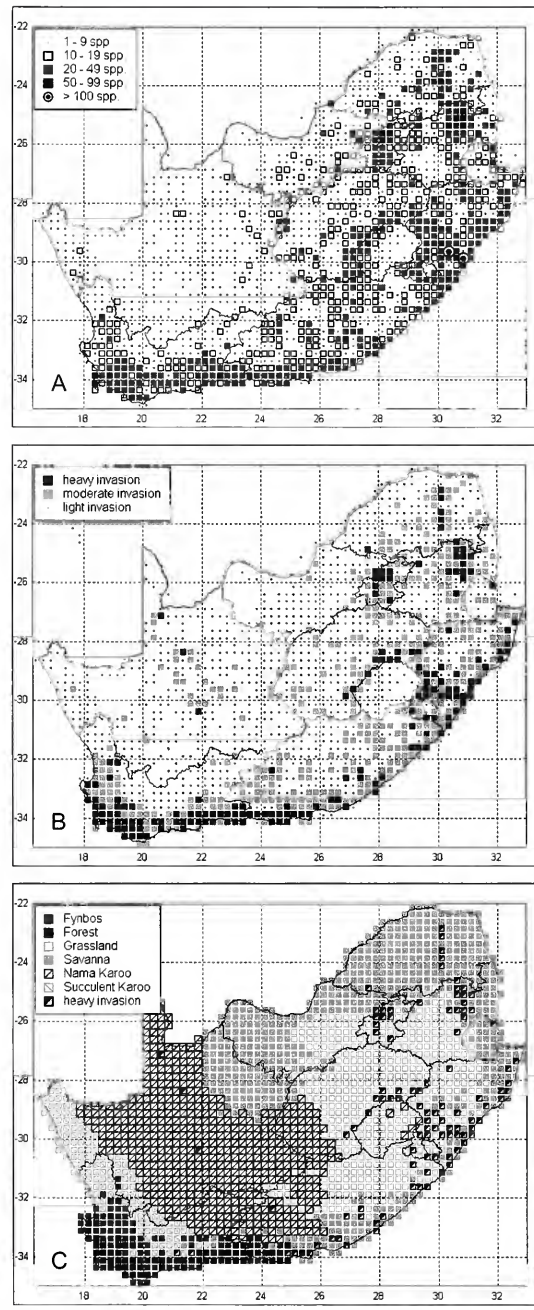

FIGURE 1.—A, species numbers per quarter-degree square in study area; B, severity of invasion per quarter-degree square. Light invasion: < 1 individual or group per km. Moderate invasion: up to 5 individuals or groups per km; some species forming stands. Heavy invasion: up to 50 individuals or groups per km; many species forming stands; some completely dominating landscape. C, heavy invasion in relation to biomes in study area.

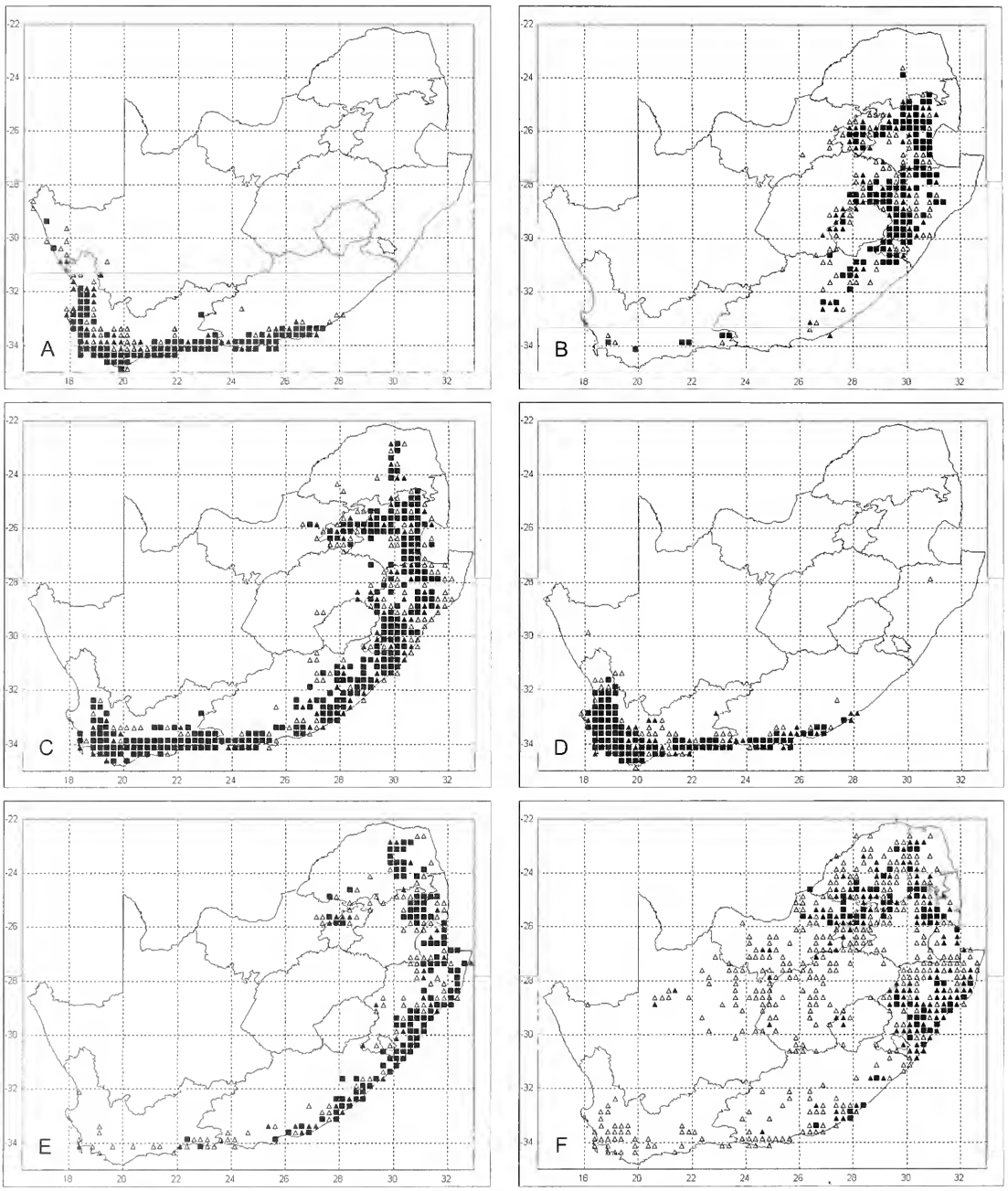

FIGURE 2.—Distribution and severity of invasion in study area: A, *Acacia cyclops*; B, *Acacia dealbata*; C, *Acacia mearnsii*; D, *Acacia saligna*; E, *Lantana camara*; F, *Melia azedarach*. Light invasion, △; moderate invasion, ▲; heavy invasion, ■.

guajava (guava), *Eichhornia crassipes* (water hyacinth) and *Jacaranda mimosifolia* (jacaranda).

Fynbos Biome

Twenty species were the most prominent invaders in the Fynbos Biome (Appendix 2). *Acacia mearnsii* was the most prominent species with a prominence value of 31.5, followed by *A. saligna* and *A. cyclops* with values of 30.4 and 27.2, respectively. The remaining top ten most prominent invaders in order, were, *Pinus pinaster* (cluster pine), *Acacia melanoxylon* (Australian blackwood), *A. longifolia* (long-leaved wattle), *Populus ×canescens* (grey poplar), *Paraserianthes lophantha* (stinkbean), *Rubus fruticosus* (European blackberry) and *Opuntia ficus-indica*. *Hakea sericea* (silky hakea) and *Pinus radiata* (radiata pine), both invaders of mountain fynbos, were most likely under-recorded because of the inaccessibility and under-sampling of this habitat.

Forest habitats

Forty species were the most prominent invaders in forest habitats (Appendix 2). *Chromolaena odorata* was

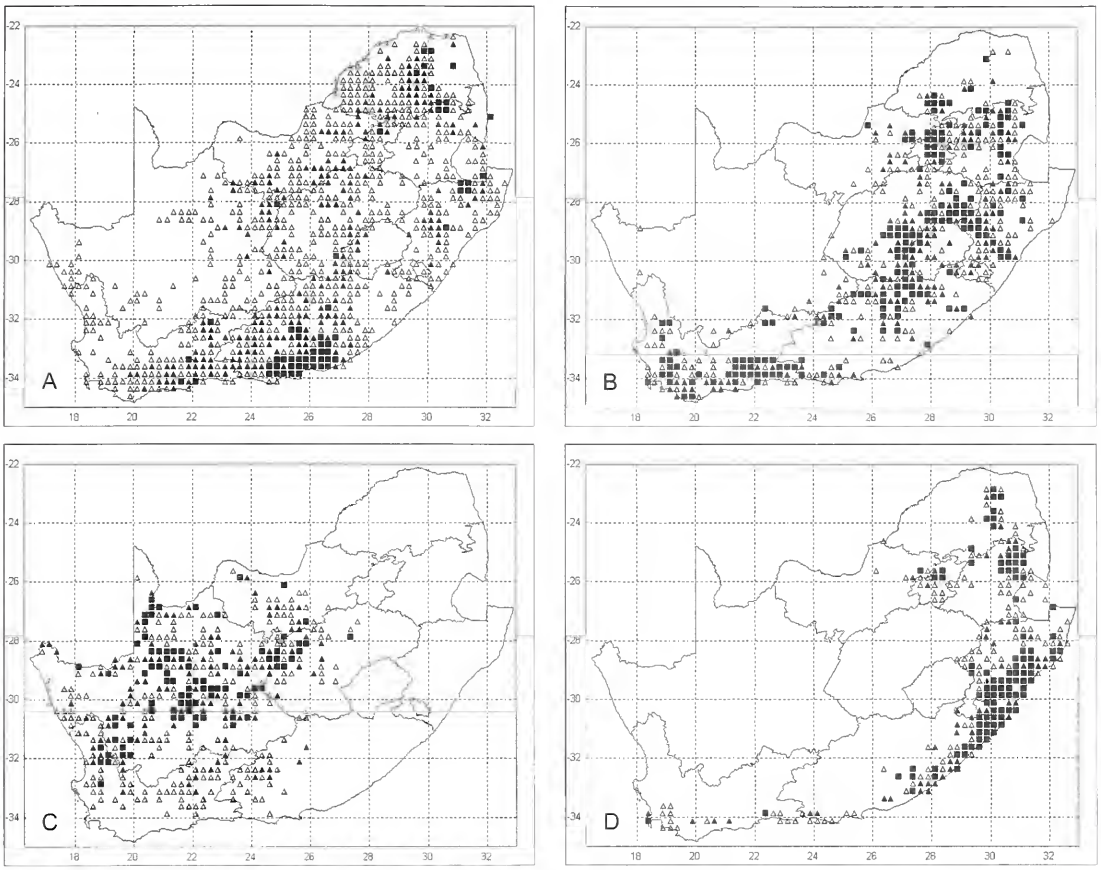

FIGURE 3.—Distribution and severity of invasion in study area: A, *Opuntia ficus-indica*; B, *Populus alba/×canescens*; C, *Prosopis* spp.; D, *Solanum mauritianum*. Light invasion, △; moderate invasion, ▲; heavy invasion, ■.

the most prominent species with a prominence value of 23.9, followed by *Solanum mauritianum* and *Acacia mearnsii* with values of 19 and 16.7, respectively. The remaining top ten prominent invaders were, in order, *Acacia melanoxylon, Lantana camara, Cestrum laevigatum* (inkberry), *Caesalpinia decapetala* (Mauritius/ Mysore thorn), *Melia azedarach, Pinus pinaster* and *Psidium guajava. Pereskia aculeata* (pereskia) ranked eleventh and could have been vastly underestimated because of the difficulty of observing this forest canopy, climbing species.

Grassland Biome

Thirty-two species were the most prominent invaders in the Grassland Biome (Appendix 3). *Acacia mearnsii* was the most prominent species with a prominence value of 21.3, followed by *A. dealbata* and *Salix babylonica* (weeping willow) with values of 20.9 and 17.3, respectively. The remaining top ten most prominent invaders were, in order, *Populus alba/×canescens* (white/grey poplars), *Solanum mauritianum*, *Rubus* spp. (mainly *R. cuneifolius)*(brambles), *Pyracantha angustifolia* and *P. crenulata* (yellow and Himalayan firethorns), *Eucalyptus* spp. (eucalypts), *Melia azedarach* and *Opuntia ficus-indica. Campuloclinium macrocephalum* (pompom weed) which did not feature as a prominent invader in this study showed an explosive rate of increase after 2000 and currently would be rated as one of the most prominent invaders in the Grassland Biome (Henderson *et al.* 2003).

Nama-Karoo Biome

Fourteen species were the most prominent invaders in the Nama-Karoo Biome (Appendix 3). *Prosopis* spp. (*P. glandulosa* var. *torreyana, P. velutina* and their hybrids) were the most prominent species with a prominence value of 60.6, followed by *Atriplex inflata* (sponge-fruit saltbush) and *Opuntia ficus-indica* with values of 21 and 14 respectively. The remaining top ten prominent invaders were, in order, *Salsola kali/tragus* (Russian tumbleweed), *Azolla filiculoides* (red water fern), *Nicotiana glauca* (wild tobacco), *Atriplex nummularia* (old man saltbush), *Schinus molle* (pepper tree), *Agave americana* (American agave) and *Solanum elaeagnifolium* (silverleaf bitter-apple).

Succulent Karoo Biome

Twelve species were the most prominent invaders in the Succulent Karoo Biome (Appendix 3). *Nicotiana glauca* was the most prominent invader with a prominence value of 26.8, followed by *Acacia cyclops* and *Prosopis* spp. (*P. glandulosa* var. *torreyana, P. velutina* and their hybrids) with values of 26.3 and 25.9, respec-

tively. The remaining top ten most prominent invaders were, in order, *Acacia mearnsii, A. saligna, Atriplex inflata, Arundo donax* (giant reed), *Atriplex nummularia, Opuntia ficus-indica* and *Populus ×canescens.*

Riparian and wetland habitats

Fifty-five species had more than 50 records in riparian and wetland habitats (Appendix 4). *Salix babylonica* was the most frequently recorded riparian and wetland species with 1 323 records, followed by *Populus alba/ ×canescens* with 1 176 records and *Acacia mearnsii* with 953 records. The remaining top ten riparian and wetland invaders were, in order, *Melia azedarach, Ricinus communis, Arundo donax, Acacia dealbata, Sesbania punicea* (red sesbania), *Prosopis* spp. and *Nicotiana glauca.*

Biome comparison

The Savanna Biome, which occupies the largest number of QDS (645) in the study area, had the greatest number of species (358) and the most invasion in terms of total abundance of all species (Table 2). The Fynbos Biome, however, which occupies the least QDS (139), was the most heavily invaded in terms of average abundance of all species per QDS, average abundance of individual species per QDS and % QDS heavily invaded. The Grassland Biome ranks third after Fynbos for total abundance of all species, followed by Forest, Nama-Karoo and the Succulent Karoo Biome was the least invaded.

Biome profiles

Appendix 6 provides species characteristics of the prominent invasive species. Table 3 analyses the prominent invasive species in each of the biomes and the study area in terms of region of origin, taxonomy, growth form, perennation, type of reproduction, dispersal mechanism and cultivated use.

TABLE 2.—Biome comparison in terms of extent, numbers and abundance of species and severity of invasion

	FB	Fh	SB	GB	NKB	SKB
Extent in QDS	139	157	645	521	548	141
Total species	216	172	358	319	105	69
Prominent invasive species	20	40	48	32	14	12
Total abundance*	986 653	222 419	1165 895	811 723	211 589	67 524
Ave abundance per QDS	7 098	1 417	1 808	1 558	386	479
Ave abundance per species	4 568	1 293	3 257	2 545	2 015	979
% QDS light#	17	15	51	49	51	66
% QDS moderate#	30	44	20	33	13	9
% QDS heavy#	47	41	8	9	1	1

QDS, quarter-degree squares in Fynbos, Savanna, Grassland, Nama-Karoo and Succulent Karoo according to Rutherford (1997); QDS in forest habitats according to SAPIA database.

*, total weighted abundance of all species (see text).

Prominent invasive species: species with highest prominence values adding up to ± upper 80% of summed values (see text).

#, % QDS lightly invaded: less than 1 individual or group per km; #, % QDS moderately invaded: up to 5 individuals or groups per km; some species forming stands; #, % QDS heavily invaded: up to 50 individuals or groups per km; many species forming stands; some completely dominating landscape.

FB, Fynbos Biome; Fh, Forest habitats; SB, Savanna Biome; GB, Grassland Biome; NKB, Nama-Karoo Biome; SKB, Succulent Karoo Biome.

Savanna Biome species are predominantly of tropical origin; members of the Fabaceae, Solanaceae, Asteraceae and Rosaceae; woody trees and shrubs, followed by herbs and climbers; perennial evergreen and evergreen/deciduous; seed-producers; water and bird dispersed; ornamentals and agricultural crops.

Fynbos Biome species are predominantly of temperate origin (particularly southern temperate); members of the Fabaceae, Myrtaceae, Pinaceae and Salicaceae; woody trees and shrubs; perennial evergreen; seed-producers; water, bird and wind dispersed; silvicultural crops, ornamentals and cover/binders.

Forest habitat species are predominantly of tropical origin; members of the Fabaceae, Asteraceae, Myrtaceae, Solanaceae, Pinaceae and Zingiberaceae; woody trees and shrubs, followed by herbs and climbers; perennial evergreen; seed-producers; bird and water dispersed; ornamentals, barriers and silvicultural crops.

Grassland Biome species are predominantly of northern temperate origin and the tropics; members of the Rosaceae, Fabaceae and Salicaceae; woody trees and shrubs, followed by herbs; perennial evergreen/deciduous and deciduous; seed-producers, but a greater percentage of species coppice and sucker than in other vegetation categories; water and bird dispersed; barriers, ornamentals and agricultural crops.

Nama-Karoo Biome species are predominantly of northern temperate origin and the tropics; members of the Chenopodiaceae, Salicaceae, Cactaceae, Fabaceae, Solanaceae and Tamaricaceae; woody trees and shrubs, followed by herbs and succulent trees and shrubs; perennial evergreen/deciduous and deciduous; seed-producers, but a greater percentage of species reproduce by vegetative division than in other vegetation categories; water and wind dispersed; agricultural crops and ornamentals.

Succulent Karoo Biome species are predominantly of temperate origin; members of the Fabaceae, Chenopodiaceae and Tamaricaceae; woody trees and shrubs; perennial evergreen and evergreen/deciduous; seed-producers and reproduce vegetatively by coppicing; water and wind dispersed; agricultural crops, ornamentals and cover/binders.

DISCUSSION

Biome comparison: extent of invasion

No previous studies have enabled a direct comparison of the extent of invasion in the different biomes using the same parameters. This study reinforces previous studies that the Fynbos Biome is the most extensively invaded vegetation type in South Africa (Richardson *et al.* 1997) but it also shows that parts of Savanna and Grassland are

TABLE 3.—Analysis of region of origin, taxonomy, growth forms, perennation, reproduction, dispersal mechanisms and cultivated uses of prominent invasive species in each of the biomes, forest habitats and study area

Characteristics	Savanna Biome (49 spp.)	Fynbos Biome (24 spp.)	Forest habitats (53 spp.)	Grassland Biome (35 spp.)	Nama-Karoo Biome (18 spp.)	Succulent Karoo Biome (16 spp.)	Study area (97 spp.)
Region of origin							
Northern temperate spp.	10 (20%)	7 (29%)	14 (26%)	18 (51%)	9 (50%)	6 (38%)	32 (33%)
Southern temperate spp.	4 (8%)	10 (42%)	6 (11%)	3 (9%)	3 (17%)	5 (31%)	15 (15%)
Tropical spp.	34 (69%)	7 (29%)	33 (62%)	13 (37%)	6 (33%)	5 (31%)	49 (51%)
Hybrid	1 (2%)			1 (3%)			1 (1%)
Taxonomy							
Families	18	12	24	14	10	10	32
Families with 50% or more of total species (no. spp. in brackets)	Fabaceae (9); Solanaceae (7); Asteraceae (5); Rosaceae (4)	Fabaceae (8); Myrtaceae (3); Pinaceae (2); Salicaceae (2)	Fabaceae (7); Asteraceae (5); Myrtaceae (4); Solanaceae (4); Pinaceae (3); Zingiberaceae (3)	Rosaceae (9); Fabaceae (6) Salicaceae (6)	Chenopodiaceae (3); Salicaceae (3); Cactaceae (2); Fabaceae (2); Solanaceae (2); Tamaricaceae (2)	Fabaceae (5); Chenopodiaceae (2); Tamaricaceae (2)	Fabaceae (15); Rosaceae (9); Solanaceae (9); Asteraceae (6); Salicaceae (6); Cactaceae (5); Myrtaceae (5)
Growth form (spp.)							
Woody tree & shrub	26 (53%)	21 (88%)	33 (62%)	26 (74%)	9 (50%)	12 (75%)	60 (62%)
Succulent tree & shrub	5 (10%)	1 (4%)	1 (2%)	1 (3%)	3 (17%)	1 (6%)	6 (6%)
Climber	7 (14%)	0	8 (15%)	1 (3%)	0	0	9 (9%)
Herbaceous	10 (20%)	1 (4%)	10 (19%)	6 (17%)	5 (28%)	2 (13%)	20 (21%)
Grass/reed	1 (2%)	1 (4%)	1 (2%)	1 (3%)	1 (6%)	1 (6%)	2 (2%)
Perennation (spp.)							
Perennial evergreen	20 (41%)	18 (75%)	33 (62%)	13 (37%)	6 (33%)	8 (50%)	51 (53%)
Perennial evergreen/ deciduous	11 (22%)	3 (13%)	9 (17%)	8 (23%)	5 (28%)	5 (31%)	19 (20%)
Perennial deciduous	7 (14%)	2 (8%)	5 (9%)	9 (26%)	5 (28%)	2 (13%)	14 (14%)
Variable	3 (6%)	1 (4%)	2 (4%)	2 (6%)	1 (6%)	1 (6%)	3 (3%)
Germinative (annual/ biennial)	8 (16%)	0	4 (8%)	3 (9%)	1 (6%)	0	10 (10%)
Reproduction (spp.) by:							
Seeds/spores	44 (90%)	21 (88%)	50 (94%)	29 (83%)	14 (78%)	14 (88%)	91 (94%)
Coppicing	23 (47%)	11 (46%)	25 (47%)	22 (63%)	8 (44%)	11 (69%)	44 (45%)
Suckering	9 (18%)	3 (13%)	6 (11%)	9 (26%)	4 (22%)	2 (13%)	14 (14%)
Division	6 (12%)	4 (17%)	3 (6%)	6 (17%)	5 (28%)	2 (13%)	10 (10%)
Rhizomes	1 (2%)	1 (4%)	4 (8%)	1 (3%)	2 (11%)	1 (6%)	6 (6%)
Stolons/runners	1 (2%)	0	3 (6%)	1 (3%)	0	0	3 (3%)
Bulbils	1 (2%)	0	0	0	0	0	1 (1%)
Dispersal (spp.) by:							
Wind	13 (27%)	7 (29%)	19 (36%)	4 (11%)	7 (39%)	6 (38%)	31 (32%)
Water	27 (55%)	16 (66%)	22 (42%)	19 (54%)	10 (56%)	11 (69%)	47 (48%)
Birds	17 (35%)	8 (33%)	25 (47%)	17 (49%)	5 (28%)	4 (25%)	40 (41%)
Mammals	9 (18%)	5 (21%)	7 (13%)	3 (9%)	4 (22%)	5 (31%)	16 (16%)
Humans	14 (29%)	5 (21%)	8 (15%)	10 (29%)	3 (17%)	3 (19%)	21 (22%)
Ants	8 (16%)	3 (13%)	4 (8%)	6 (17%)	0	2 (13%)	10 (10%)
Cultivated uses (spp.)							
Ornamental	20 (41%)	6 (25%)	21 (40%)	7 (20%)	5 (28%)	4 (25%)	35 (36%)
Cover/binder	4 (8%)	5 (21%)	6 (11%)	4 (11%)	2 (11%)	3 (19%)	9 (9%)
Barrier	5 (10%)	2 (8%)	9 (17%)	8 (23%)	2 (11%)	0	17 (18%)
Silvicultural crop	2 (4%)	7 (29%)	8 (15%)	4 (11%)	0	2 (13%)	10 (10%)
Agricultural crop	11 (22%)	4 (17%)	7 (13%)	7 (20%)	7 (39%)	7 (44%)	16 (16%)
Species with no uses	7 (14%)	0	2 (4%)	5 (14%)	2 (11%)	0	11 (11%)

as heavily invaded as parts of the Fynbos. These findings have important implications for the management of alien plant invasions in South Africa. Without intervention we can expect invasion to increase in all parts of South Africa and particularly in the Grassland and Savanna Biomes where large areas are yet to be invaded and many species are only starting to invade.

Biome comparison: prominent invaders

Each biome has a different suite of prominent invaders. In part, this can be explained by their pre-adaption to the prevailing environmental conditions, but also to their history of planting. Most of these species were deliberately introduced and cultivated on a grand scale as silvicultural and agricultural crops e.g. *Acacia mearnsii*, *A. melanoxylon, Pinus pinaster* and species of *Prosopis*, as barriers e.g. *Acacia dealbata*, *Hakea sericea* and *Pyracantha angustifolia*, as cover/binders e.g. *Acacia cyclops, A. saligna* and *Populus ×canescens*, and ornamentals e.g. *Melia azedarach* and *Lantana camara.*

Some species which have become prominent invaders were not cultivated widely or on a grand scale e.g. *Solanum mauritianum, Chromolaena odorata* and *Nicotiana glauca.* Although the latter species have on occasion been cultivated as ornamentals they have managed to disperse very efficiently without human assistance—*C. odorata* by wind, *S. mauritianum* by birds and *N. glauca* by wind, soil and water.

Some species, although widely planted, have become prominent invaders in only one biome, indicating that environmental factors have limited their distribution. Examples are members of the family Rosaceae, such as *Pyracantha angustifolia, P. crenulata, Cotoneaster franchetii* and *C. pannosus* that are virtually restricted to high-altitude grasslands where it appears that freezing winter temperatures are needed to trigger seed germination (Henderson 1989). *Jacaranda mimosifolia* is another species that has been planted throughout South Africa yet is only invasive in the moister parts of the Savanna and Forest Biomes. In its native northeastern Argentina, *J. mimosifolia* occurs mainly on river banks under warmer-temperate, subhumid conditions (Poynton 1973)—environmental conditions which are similar to those in its naturalized range in southern Africa. A previous study by Henderson (2006b) showed that the current distributions of invasive plants in southern Africa are a reflection of the climatic zones of their origin.

There are considerable differences in the species profiles of the biomes but shared features are the prominence of the family Fabaceae, woody trees and shrubs, reproduction by seed and water dispersal. Within the Fabaceae the *Acacia* species are the most numerous with 17 listed species and account for a very large proportion of all plant invasion in South Africa. They are important invaders of all the major vegetation types except for those in the arid interior, where other leguminous invaders take over, namely species of *Prosopis.* The most widespread and abundant acacias are *Acacia mearnsii, A. cyclops* and *A. saligna. Acacia mearnsii* has invaded the widest range of vegetation types in South Africa and is the most widespread riverine invader, occurring almost continuously from Louis Trichardt in the Limpopo Province down the eastern seaboard to Cape Town, a distance of ± 2 500 km. *Acacia cyclops* stretches along almost the entire Cape coastline from Port Nolloth in the northwest to beyond East London in the east, a distance exceeding 2 000 km. *Acacia saligna* stretches along the Cape coastline from Saldanha Bay in the west to the Kei River in the east, a distance of ± 1 500 km.

Sixty-eight per cent of prominent invaders are perennial trees or shrubs. There are only two grasses listed as prominent invaders and only 14 species as nonperennial (annual, biennial or variable). Grasses and herbaceous species are under-represented in the SAPIA database largely as a consequence of biassed recording of the larger, more conspicuous species. In southern Africa the Poaceae is one of the largest plant families with 847 indigenous species and 115 (12%) naturalized species (Gibbs Russell *et al.* 1990). However, only 30 grass species are listed in this publication. There is definitely a lack of expertise in identifying grasses in South Africa and this is one of the reasons for the under-representation of alien grasses in weed surveys. There is similarly an under-representation of the alien herbaceous Asteraceae. The South African National Biodiversity Institute's online species checklist at http://posa.sanbi.org/searchspp.php lists 125 alien herbaceous species in South Africa, yet only 44 alien herbaceous species have been listed in this publication.

Comparison with other studies

Versfeld *et al.* (1998) provide the only other assessment of the extent and importance of invasive plants on a national level. This study combined expert knowledge of local landowners and managers with existing databases such as those of provincial conservation authorities and national departments. The SAPIA database was used as a means of data verification particularly for areas where expert knowledge was lacking. Overall the assessment by Versfeld *et al.* (1998) relating to importance rankings and the distribution of dense infestations concurs with this study. Eight of the top ten invading species or groups of species, ranked by condensed invaded area, also appear within the top ten ranking in this study—these are: *Acacia cyclops, Prosopis* spp., *A. mearnsii, A. saligna, Solanum mauritianum, Opuntia* spp., *Melia azedarach* and *Lantana camara.* Versfeld *et al.* (1998) include *Pinus* spp. and *Hakea* spp. within the top ten ranking, whereas this study includes *Populus alba/×canescens* and *Acacia dealbata.* The lower ranking of *Pinus* spp. and *Hakea* spp. in this study can be explained by the under-sampling of mountain habitats, which are largely inaccessible by road, in which these species are invasive.

Abundance data presented in this study suggests that Versfeld *et al.* (1998) may have underestimated the area of invasion of *Salix babylonica* and *Populus alba/×canescens.* In the present study these species were not only the most frequently recorded invaders in riparian and wetland habitats but their total weighted abundance

was in both instances more than *Melia azedarch* and *Eucalyptus* spp. (Appendix 1) which were rated above *Salix* spp. and *Populus* spp. by Versfeld *et al.* (1998). Other riparian species which may also have been underestimated include *Arundo donax* (giant reed), *Morus alba* (common mulberry) and *Ricinus communis.*

Looking to the future

The Working for Water Programme (WfW) and biological control

Alien plant invasion is a dynamic process and there will undoubtedly be changes in species composition and prominence of invaders in the future. Many of the large tree species—mainly *Acacia, Eucalyptus, Pinus, Populus*, *Prosopis* species and *Melia azedarach* have been targeted by a national clearing programme, Working for Water (WfW), which started in October 1995 (Marais *et al.* 2004). To date there has not been an assessment of the affects of the WfW programme on the status of invasive alien infestations. The programme has been proposed for 20 years but Marais *et al.* (2004) indicate that even with the existing generous levels of funding, it is unlikely that the problem will be contained within the next half century.

Biological control of invasive plants using introduced insects and pathogens is the only sustainable, effective and inexpensive solution to the most intractable of the invasive alien plant problems (Marais *et al.* 2004). When they are successful, the damage inflicted by biological control agents causes a decline in population densities, distribution and, or, rates of spread of invasive plants, and reduces the costs of other management practices (Zimmermann *et al.* 2004). There have been some outstanding successes with biocontrol in South Africa, dating back to the early and mid-1900s with *Opuntia monacantha* (drooping prickly pear) and *O. ficus-indica,* and in more recent years with several of the *Acacia* spp. (Zimmermann *et al.* 2004). Population monitoring of *A. saligna* in the Western Cape has shown marked decreases in population densities caused by the gall-forming rust fungus, *Uromycladium tepperianum* (Morris 1997; Wood & Morris 2007).

New invaders

Since 2000 a further 45 species have been added to the SAPIA database for the study area (Appendix 5). Another eight species, two of which are indigenous to South Africa, are naturalized in neighbouring Zimbabwe and Malawi (Appendix 5). All but three of the additional species have been listed as weeds in *A global compendium of weeds* (Randall 2002) and 28 species are environmental weeds elsewhere in the world and therefore have the potential to become invasive in South Africa. Fourteen of the new species are 'noxious weeds' or restricted in California, Florida, Hawaii, New Zealand and Australia—places with similar climates and with which South Africa has many invasive species in common. We should be especially wary of these species which include some of the most damaging and costly invaders such as *Hydrilla verticillata* (hydrilla), a submerged aquatic plant that has invaded much of the USA since the 1960s, and *Chondrilla juncea* (skeleton weed), a terrestrial herb that has become a major agricultural weed in the USA, Canada and Australia.

CONCLUSION

The main objective of this paper was to provide a historical overview of the extent and species composition of alien plant invasion in southern Africa from 1979 until the end of 2000. This snapshot of invasion will provide a yardstick by which we can measure our progress or failure in the management of invasive alien plants in southern Africa.

This publication will also contribute to the global knowledge of invasive alien plants. One of the most useful predictors of invasiveness is whether a species is invasive elsewhere in the world (Richardson *et al.* 2004a). The lists of prominent invaders and other naturalized species provided here will serve as a warning to neighbouring countries and to those as far afield as Australia, New Zealand and the USA of potentially invasive species in their regions.

The results presented here are but a summary of the more than 50 000 records of invasive alien plants in the SAPIA database. Much more can be gleaned from the SAPIA data. SAPIA has provided the raw data for analyses that have been used to prioritize invasive alien species for management (Robertson *et al.* 2003; Nel *et al.* 2004), to map the potential spread of invasive plants (Rouget *et al.* 2004), to look at broad-scale distribution patterns of invasive species (Richardson *et al.* 2004b), to correlate patterns of alien plant species richness with the environment and indigenous species richness (Richardson *et al.* 2005), to correlate patterns of invasion with interactions between environment, species traits and human uses (Thuiller *et al.* 2006) and to look at potential range and residence time (Wilson *et al.* 2007). SAPIA has also played a crucial role in providing information on invasive plants for the revision of the Conservation of Agricultural Resources Act, Act 43 of 1983, and the drafting of the National Environmental Management: Biodiversity Act, Act 10 of 2004.

Alien plant invasion is a dynamic process and therefore it is essential that the SAPIA database be kept up-to-date with current information. From October 2006 a second phase of the SAPIA mapping project was launched and all the SAPIA data will be available online at the Weeds and Invasive Plants (WIP) website, www.agis.agric.za/wip (Henderson 2006a).

ACKNOWLEDGEMENTS

I thank all the people who have contributed in many different ways to the compilation of the SAPIA database and have made it one of the most comprehensive databases on invasive alien plants in southern Africa. Les Powrie and Mike Rutherford of the South African National Biodiversity Institute are thanked for the QDS

coverage of the biomes of South Africa which was used to subdivide the SAPIA dataset into the six biome datasets for this publication. Special tribute is made to Mike Wells of the Botanical Research Institute for his inspiration and mentorship during the development of roadside survey techniques from 1979 to the mid-1980s, and to Helmuth Zimmermann of the Plant Protection Research Institute for his motivation and support of the SAPIA mapping project. SAPIA is an initiative of the Agricultural Research Council (ARC): Plant Protection Research Institute which has provided the infrastructure, basal funding and support since the mid 1980s to the present. External funding of SAPIA has been gratefully received from the Departments of Agriculture, Environmental Affairs and Tourism, and Water Affairs and Forestry (Working for Water Programme).

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APPENDIX 1.—Prominent invaders in study area

Scientific name	QSp	QSa	Tr	A	Pv	R
Acacia						
cyclops	166	91	1 097	203 636	**8.66**	4
dealbata	256	115	1 079	133 146	**6.45**	9
decurrens	101	31	232	23 456	**1.23**	
longifolia	94	34	363	53 080	**2.43**	
mearnsii	428	251	2 620	410 950	**18.37**	1
melanoxylon	134	29	482	43 926	**2.40**	
pycnantha	35	15	135	13 864	**1.77**	
saligna	158	93	1 030	219 223	**9.00**	2
Achyranthes aspera	77	3	85	1 262	0.22	
Agave						
americana	431	8	761	9 136	**1.94**	
sisalana	170	12	293	8 924	**0.91**	
Ageratum						
conyzoides	37	8	50	5 141	0.27	
conyzoides/houstonianum	31	8	49	2 994	0.20	
houstonianum	26	2	31	1 728	0.12	
Argemone						
mexicana	27	5	36	2 134	0.14	
ochroleuca	154	20	206	12 115	**0.82**	
sp.	14	2	15	1 338	0.07	
Arundo donax	371	82	855	50 158	**3.41**	
Atriplex						
inflata	164	77	213	58 878	**2.28**	
nummularia	172	18	333	10 248	**1.04**	
Azolla filiculoides	194	92	354	47 220	**2.23**	
Caesalpinia decapetala	127	41	413	33 868	**1.94**	
Cardiospermum						
grandiflorum	43	12	57	4 905	0.28	
grandiflorum/ halicacabum	16	5	20	2 427	0.12	
Cereus jamacaru	124	11	193	13 042	0.82	
Cestrum laevigatum	70	16	167	11 039	0.70	
Chromolaena odorata	93	64	558	137 654	**5.46**	
Cinnamomum camphora	10	1	19	352	0.05	
Cirsium vulgare	188	20	345	14 022	**1.18**	
Datura						
ferox	175	14	201	8 685	0.71	
innoxia	29	3	36	1 897	0.14	
sp.	84	1	110	1 710	0.29	
stramonium	286	24	373	12 932	**1.21**	
Eichhornia crassipes	87	72	431	79 893	**3.40**	
Eucalyptus						
camaldulensis	121	22	182	13 259	**0.80**	
diversicolor	49	8	153	5 562	**0.50**	
grandis	100	16	190	14 475	**0.86**	
sp.	505	30	1 103	23 523	**3.12**	
Hakea sericea	77	17	230	15 959	**0.99**	
Ipomoea						
indica	23	3	27	740	0.08	
indica/purpurea	74	7	120	2 284	0.33	
purpurea	37	3	46	1 801	0.16	
sp.	3	0	3	52	0.01	
Jacaranda mimosifolia	195	16	613	17 430	**1.87**	
Lantana camara	247	116	2 111	140 496	**8.92**	3
Leptospermum laevigatum	38	15	102	15 916	0.71	
Litsea glutinosa	8	3	10	2 713	0.11	
Macfadyena unguis-cati	22	9	52	9 531	0.41	
Melia azedarach	551	65	2 119	65 735	**6.64**	8
Morus alba	129	8	304	5 983	0.85	
Nephrolepis exaltata	13	1	19	459	0.06	
Nicotiana glauca	383	14	957	22 132	**2.76**	
Opuntia						
ficus-indica	861	57	2 445	72 477	**7.55**	5
robusta	225	2	337	3 244	0.83	
stricta	106	14	193	5 412	0.59	
Paraserianthes lophantha	54	9	286	20 042	**1.24**	
Passiflora edulis	32	0	55	261	0.13	
Pennisetum clandestinum	48	12	53	8 884	0.39	
Pereskia aculeata	44	8	102	5 788	0.40	
Pinus						
patula	85	13	238	11 636	0.88	
pinaster	85	44	401	48 229	**2.36**	
radiata	70	15	206	9 243	0.73	
Populus						
alba	15	2	22	915	**0.08**	7
alba/canescens	185	47	460	33 871	**2.04**	7
×canescens	371	130	939	87 397	**4.74**	7
Prosopis						
glandulosa	40	10	50	4 988	**0.26**	10
glandulosa/velutina	390	78	1 107	92 751	**5.27**	10
velutina	48	6	53	3 108	**0.21**	10
Prunus persica	319	1	728	7 401	**1.81**	
Psidium guajava	160	50	732	55 791	**3.31**	
Pyracantha angustifolia	142	3	285	3 735	0.74	
Pyracantha angustifolia/crenulata	40	3	51	1 183	0.15	
Ricinus communis	456	56	1 701	48 855	**5.21**	
Robinia pseudoacacia	110	14	178	8 828	0.66	
Rosa rubiginosa	119	12	276	11 494	**0.95**	
Rubus						
cuneifolius	75	35	236	49 313	**2.03**	
fruticosus	89	32	244	22 810	**1.23**	
pascuus	3	2	3	450	**0.02**	
sp.	86	30	179	29 694	**1.30**	
×proteus	4	3	4	650	**0.03**	
Salix						
babylonica	475	89	1 381	85 116	**5.63**	
fragilis	75	24	176	15 710	0.87	
Salsola kali/tragus	155	31	187	14 080	0.84	
Schinus molle	231	2	407	5 355	**1.05**	
Senna didymobotrya	139	29	339	16 342	**1.24**	
Sesbania punicea	323	68	830	52 078	**3.41**	
Solanum						
elaeagnifolium	51	11	60	14 136	0.57	
mauritianum	265	99	1 364	135 219	**7.14**	6
seaforthianum	30	3	77	2 656	0.25	
Tithonia diversifolia	49	5	123	4 085	0.39	
Xanthium strumarium	149	21	212	12 633	0.85	

Combined taxa e.g. *Ageratum conyzoides/houstonianum* indicate uncertainty of identification.

QSp, quarter-degree squares present; QSa, quarter-degree squares abundant; Tr, total records; A, total weighted abundance (see text); Pv, prominence value (bold numbers: highest prominence values which add up to ± upper 80% of summed values—see text); R, ranking of top ten taxa (taxa that are difficult to distinguish are grouped together).

APPENDIX 2.—Prominent invaders in Savanna Biome, Fynbos Biome and Forest habitats

	Savanna Biome					Fynbos Biome					Forest Habitats				
Scientific name	QSp	QSa	R	A	Pv	QSp	QSa	R	A	Pv	QSp	QSa	R	A	Pv
Acacia															
cyclops	31	20	181	28 557	**3.40**	102	63	810	174 964	**27.20**	5	0	9	214	0.73
dealbata	39	13	132	12 207	**1.74**	7	3	23	4 887	0.76	12	3	12	3 361	**2.36**
decurrens	19	7	38	1 779	0.35						4	1	4	1 061	0.76
longifolia	27	7	66	9 183	1.14	47	24	264	39 533	**7.09**	13	3	13	1 642	**1.65**
mearnsii	134	59	710	75 210	**10.20**	88	70	871	210 388	**31.50**	36	22	91	22 825	**16.70**
melanoxylon	33	2	73	1 274	0.49	50	23	298	38 206	**7.35**	25	12	85	18 186	**14.20**

Combined taxa e.g. *Ageratum conyzoides/houstonianum* indicate uncertainty of identification. QSp, quarter-degree squares present; QSa, quarter-degree squares abundant; R, records; A, total weighted abundance (see text); Pv, prominence value (bold numbers: highest prominence values which add up to ± upper 80% of summed values—see text).

APPENDIX 2.—Prominent invaders in Savanna Biome, Fynbos Biome and Forest habitats (cont.)

Scientific name	Savanna Biome					Fynbos Biome					Forest Habitats				
	QSp	QSa	R	A	Pv	QSp	QSa	R	A	Pv	QSp	QSa	R	A	Pv
Acacia (cont.)															
pycnantha	3	1	4	203	0.04	32	14	131	13 661	**2.92**					
saligna	27	11	96	12 170	**1.55**	105	74	860	200 582	**30.40**	4	2	8	1 313	**1.15**
Achyranthes aspera	40	3	44	1 078	0.32	5	0	5	5	0.06	10	2	12	468	**1.05**
Agave															
americana	146	3	267	3 986	**1.75**	39	0	84	427	1.02	2	0	2	51	0.16
sisalana	132	12	251	8 801	**2.08**	10	0	10	46	0.12	3	0	4	22	0.29
Ageratum															
conyzoides	32	8	44	4 979	**0.66**						1	0	1	1	0.07
conyzoides/houstonianum	27	6	45	2 583	**0.46**	1	0	1	1	0.01	12	3	13	726	**1.24**
houstonianum	22	2	26	1 625	**0.28**						8	2	8	1 261	**1.13**
Argemone															
mexicana	23	4	32	1 082	**0.26**	1	1	1	1 000	0.11	1	0	1	50	0.09
ochroleuca	86	13	119	7 190	**1.24**	2	1	2	201	0.04	1	0	1	50	0.09
sp.	6	2	7	1 272	**0.15**										
Arundo donax	132	34	372	20 126	**3.69**	71	25	172	16 721	**3.70**	3	1	3	1 020	0.67
Atriplex															
inflata	13	9	16	7 701	0.75	19	10	25	7 148	1.02					
nummularia	11	3	18	2 336	0.30	24	1	45	851	0.61					
Azolla filiculoides	43	16	75	4 979	0.83	16	10	37	7 491	1.19	2	2	2	400	0.32
Caesalpinia decapetala	80	22	239	20 966	**3.06**						17	7	25	6 053	**4.48**
Cardiospermum															
grandiflorum	40	11	54	4 703	**0.69**						5	3	7	1 511	**1.17**
grandiflorum/halicacabum	14	5	18	2 416	**0.30**						4	2	4	1 251	0.84
Cereus jamacaru	100	11	169	12 857	**1.99**	6	0	6	6	0.07	1	0	1	10	0.07
Cestrum laevigatum	48	12	138	7 551	**1.38**	6	0	9	58	0.11	22	9	30	6 457	**5.01**
Chromolaena odorata	79	57	529	133 524	**14.20**						33	25	77	41 029	**23.90**
Cinnamomum camphora	7	1	13	346	0.10	2	0	3	3	0.04	7	1	14	347	**1.14**
Cirsium vulgare	43	4	68	1 708	0.51	8	0	8	75	0.10					
Datura															
ferox	69	3	87	2 676	**0.69**	3	0	3	3	0.04	2	0	2	11	0.15
innoxia	23	1	30	1 435	**0.28**	1	0	1	50	0.02	1	0	1	50	0.09
sp.	34	0	41	581	**0.27**	1	1	1	200	0.03					
stramonium	104	9	131	4 082	**1.04**	15	1	19	1 357	0.36	6	1	6	1 170	0.95
Eichhornia crassipes	46	44	279	60 302	**6.64**	20	7	46	5 591	1.10					
Eucalyptus															
camaldulensis	23	4	36	1 993	0.36	41	13	81	6 318	1.59	3	2	3	2 050	**1.13**
diversicolor	1	0	1	1	0.01	44	7	148	5 349	**2.27**	12	4	28	1 897	**2.82**
grandis	54	8	111	9 827	**1.43**	1	0	1	10	0.01	15	2	19	974	**1.77**
sp.	122	8	299	7 242	**2.20**	72	10	147	4 838	**2.21**	8	2	17	687	**1.51**
Hakea sericea	7	2	14	537	0.12	61	14	204	14 344	**3.84**	3	0	3	61	0.24
Ipomoea															
indica	18	3	22	735	**0.18**	3	0	3	3	0.04	3	0	3	3	0.21
indica/purpurea	49	3	86	1 101	**0.55**	10	1	18	409	0.25	11	2	16	1 308	**1.71**
purpurea	18	1	23	410	**0.16**	7	2	10	1 271	0.25	7	1	9	1 102	**1.13**
sp.	2	0	2	51	**0.01**										
Jacaranda mimosifolia	139	16	497	16 767	**4.06**						17	2	21	1 589	**2.19**
Lantana camara	162	90	1 843	126 418	**20.60**	25	2	60	3 462	1.05	40	28	63	17 136	**12.10**
Leptospermum laevigatum	3	3	6	701	0.09	35	12	96	15 215	**2.66**	2	0	3	21	0.22
Litsea glutinosa	8	3	10	2 713	0.29						4	2	6	2 451	**1.52**
Macfadyena unguis-cati	17	6	47	8 880	**1.01**						6	5	13	4 912	**3.12**
Melia azedarach	291	53	1 394	54 100	**12.00**	44	0	82	181	0.98	17	5	29	4 856	**4.22**
Morus alba	72	6	192	3 986	**1.35**	2	1	2	11	0.02	6	1	10	481	0.92
Nephrolepis exaltata	10	1	12	318	0.09	2	0	6	131	0.08	9	1	13	337	**1.07**
Nicotiana glauca	126	7	274	7 812	**2.11**	51	2	168	3 657	**2.33**	1	0	1	50	0.09
Opuntia															
ficus-indica	330	39	1 159	47 136	**10.10**	73	5	267	7 242	**3.85**	8	5	8	4 261	**2.48**
robusta	50	0	61	191	0.34	12	1	13	1 048	0.26					
stricta	82	13	168	5 112	**1.32**	1	0	1	50	0.02					
Paraserianthes lophantha	5	0	10	104	0.06	47	9	274	19 936	**5.22**	7	0	7	34	0.51
Passiflora edulis	22	0	40	192	0.23	5	0	6	24	0.07	13	0	19	64	**1.37**
Pennisetum clandestinum	10	3	12	2 414	0.27	26	4	28	2 106	0.54	3	3	3	3 000	**1.56**
Pereskia aculeata	34	7	91	5 569	0.96	4	0	4	13	0.05	14	4	39	2 963	**4.08**
Pinus															
patula	30	7	90	6 154	1.00						14	5	18	1 194	**1.80**
pinaster	13	5	34	6 549	0.74	66	36	355	39 368	**8.14**	9	4	29	4 586	**4.10**
radiata	3	0	4	53	0.03	53	15	186	8 902	**3.08**	4	3	20	1 235	**1.96**
Populus															
alba	6	0	11	350	**0.09**	1	0	1	50	0.02					
alba/canescens	51	22	171	15 598	**2.24**	1	0	1	50	0.02	8	2	8	611	0.84
×canescens	36	8	76	5 390	**0.86**	82	34	279	24 456	**5.74**	3	0	4	22	0.29
Prosopis															
glandulosa	7	5	13	1 421	**0.19**	2	0	2	51	0.03					

Combined taxa e.g. *Ageratum conyzoides/houstonianum* indicate uncertainty of identification. QSp, quarter-degree squares present; QSa, quarter-degree squares abundant; R, records; A, total weighted abundance (see text); Pv, prominence value (bold numbers: highest prominence values which add up to ± upper 80% of summed values—see text).

APPENDIX 2.—Prominent invaders in Savanna Biome, Fynbos Biome and Forest habitats (cont.)

Scientific name	Savanna Biome					Fynbos Biome					Forest Habitats				
	QSp	QSa	R	A	Pv	QSp	QSa	R	A	Pv	QSp	QSa	R	A	Pv
Prosopis (cont.)															
glandulosa/velutina	64	5	168	4 869	**1.30**	22	2	63	1 657	0.90					
velutina	6	1	7	257	**0.06**	3	0	3	52	0.04					
Prunus persica	53	0	115	933	0.69	41	0	65	191	0.78	1	0	1	1	0.07
Psidium guajava	124	45	662	53 388	**8.07**	6	0	9	45	0.11	14	8	25	5 174	**4.09**
Pyracantha															
angustifolia	6	0	13	40	0.07	5	0	6	15	0.07	2	0	2	2	0.14
angustifolia/crenulata	5	0	5	5	0.03	2	0	2	2	0.02	1	0	1	50	0.09
Ricinus communis	256	46	1 230	40 996	**10.00**	87	7	250	4 189	**3.35**	25	5	30	1 618	**2.84**
Robinia pseudoacacia	10	0	13	80	0.08	6	0	6	15	0.07	1	0	1	1	0.07
Rosa rubiginosa	8	0	12	128	0.07	4	0	6	162	0.09	2	0	2	51	0.16
Rubus															
cuneifolius	18	4	45	10 711	**1.16**						5	3	6	2 451	**1.52**
fruticosus	15	4	24	2 146	**0.31**	55	21	188	16 874	**3.91**	7	3	14	1 701	**1.75**
pascuus	2	1	2	250	**0.03**										
sp.	31	7	88	8 076	**1.16**	5	2	5	430	0.10	10	1	12	443	**1.04**
×*proteus*	2	2	2	400	**0.05**										
Salix															
babylonica	67	5	140	3 609	**1.05**	38	3	74	1 838	1.05	6	0	6	211	0.52
fragilis	2	0	5	121	0.04	1	1	1	200	0.03					
Salsola kali/tragus	22	2	27	1 027	0.23	12	1	13	511	0.20					
Schinus molle	52	0	82	463	0.47	24	0	49	358	0.61	1	0	1	10	0.07
Senna didymobotrya	103	25	261	14 239	**2.60**	3	0	3	3	0.04	12	1	15	406	**1.24**
Sesbania punicea	139	26	405	21 438	**3.97**	60	19	175	17 026	**3.77**	7	0	8	66	0.59
Solanum															
elaeagnifolium	18	0	18	183	0.11	3	1	3	251	0.06					
mauritianum	123	52	748	77 619	**10.60**	28	2	86	2 035	1.21	66	32	97	27 090	**19.00**
seaforthianum	28	3	75	2 636	0.62	1	0	1	10	0.01	9	0	31	263	**2.30**
Tithonia diversifolia	46	5	120	4 033	**0.98**						8	0	10	313	0.84
Xanthium strumarium	74	16	126	8 577	**1.40**	2	1	3	251	0.06	4	0	4	62	0.31

Combined taxa e.g. *Ageratum conyzoides/houstonianum* indicate uncertainty of identification. QSp, quarter-degree squares present; QSa, quarter-degree squares abundant; R, records; A, total weighted abundance (see text); Pv, prominence value (bold numbers: highest prominence values which add up to ± upper 80% of summed values—see text).

APPENDIX 3.—Prominent invaders in Grassland Biome, Nama-Karoo Biome and Succulent Karoo Biome

Scientific name	Grassland Biome					Nama-Karoo Biome					Succulent Karoo Biome				
	QSp	QSa	R	A	Pv	QSp	QSa	R	A	Pv	QSp	QSa	R	A	Pv
Acacia															
cyclops						1	0	1	10	0.04	32	8	105	12 150	**26.30**
dealbata	206	99	922	116 050	**20.90**	2	0	2	2	0.06					
decurrens	82	24	194	21 677	**4.06**										
longifolia	19	3	31	4 362	0.76						1	0	2	2	0.16
mearnsii	197	116	1 003	114 979	**21.30**						9	6	36	10 373	**18.20**
melanoxylon	49	4	109	4 435	1.33						2	0	2	11	0.18
saligna	2	0	2	11	0.02						24	8	72	6 471	**15.30**
Achyranthes aspera	30	0	34	128	0.26	2	0	2	51	0.09					
Agave															
americana	148	2	219	2 507	1.87	81	3	160	1 961	**5.90**	17	0	31	255	2.84
sisalana	21	0	25	52	0.19	3	0	3	21	0.10	4	0	4	4	0.32
Ageratum															
conyzoides	5	0	6	162	0.06										
conyzoides/houstonianum	3	2	3	410	0.07										
houstonianum	4	0	5	103	0.05										
Argemone															
mexicana	3	0	3	52	0.03										
ochroleuca	38	2	56	1 155	0.54	26	4	27	3 549	2.52	2	0	2	20	0.19
sp.	1	0	1	10	0.01	1	0	1	1	0.03	6	0	6	55	0.56
Arundo donax	89	8	188	5 068	**1.97**	51	8	77	2 927	**3.80**	28	7	46	5 316	**11.50**
Atriplex															
inflata	3	1	4	460	0.09	83	42	107	37 882	**21.00**	46	15	61	5 687	**13.30**
nummularia	4	0	6	153	0.06	88	11	181	4 732	**7.90**	45	3	83	2 176	**9.81**
Azolla filiculoides	88	41	172	21 806	**3.92**	47	25	70	12 944	**8.30**					
Caesalpinia decapetala	47	19	174	12 902	**2.83**										
Cardiospermum															
grandiflorum	3	1	3	202	0.05										
grandiflorum/halicacabum	2	0	2	11	0.02										
Cereus jamacaru	12	0	12	106	0.10	6	0	6	73	0.22					
Cestrum laevigatum	16	4	20	3 430	0.57										

Combined taxa e.g. *Ageratum conyzoides/houstonianum* indicate uncertainty of identification. QSp, quarter-degree squares present; QSa, quarter-degree squares abundant; R, records; A, total weighted abundance (see text); Pv, prominence value (bold numbers: highest prominence values which add up to ± upper 80% of summed values—see text).

APPENDIX 3.—Prominent invaders in Grassland Biome, Nama-Karoo Biome and Succulent Karoo Biome (cont.)

	Grassland Biome					Nama-Karoo Biome					Succulent Karoo Biome				
Scientific name	QSp	QSa	R	A	Pv	QSp	QSa	R	A	Pv	QSp	QSa	R	A	Pv
Chromolaena odorata	14	7	29	4 130	0.72										
Cinnamomum camphora	1	0	3	3	0.02										
Cirsium vulgare	126	14	253	10 776	**3.14**	11	2	16	1 463	1.19					
Datura															
ferox	82	9	85	3 429	**1.03**	21	2	26	2 566	2.03					
innoxia	3	2	3	401	**0.68**	2	0	2	11	0.07					
sp.	46	0	65	877	**0.57**	2	0	2	2	0.06	1	0	1	50	0.15
stramonium	126	12	174	6 224	**2.01**	40	2	48	1 259	2.10	1	0	1	10	0.09
Eichhornia crassipes	21	21	106	14 000	**2.48**										
Eucalyptus															
camaldulensis	16	3	17	2 406	0.42	14	2	14	2 195	1.48	27	0	34	347	3.21
diversicolor	2	1	2	210	0.04						2	0	2	2	0.16
grandis	45	8	78	4 638	**1.13**										
sp.	276	12	614	11 153	**5.76**	21	0	27	188	0.93	14	0	16	102	1.42
Hakea sericea	1	0	1	50	0.01						8	1	11	1 028	2.40
Ipomoea															
indica	2	0	2	2	0.01										
indica/purpurea	15	3	16	774	0.21										
purpurea	12	0	13	120	0.11										
sp.	1	0	1	1	0.01										
Jacaranda mimosifolia	55	0	115	662	0.90	1	0	1	1	0.03					
Lantana camara	59	24	207	10 606	**2.79**						1	0	1	10	0.09
Macfadyena unguis-cati	5	3	5	651	0.12										
Melia azedarach	177	12	588	11 198	**5.58**	36	0	49	250	1.65	3	0	6	6	0.49
Morus alba	54	2	109	1 985	1.02	1	0	1	1	0.03					
Nephrolepis exaltata	1	0	1	10	0.01										
Nicotiana glauca	48	1	72	1 266	0.67	92	2	206	3 980	**8.30**	66	2	237	5 417	**26.80**
Opuntia															
ficus-indica	257	10	570	11 437	**5.48**	161	3	368	5 688	**14.00**	40	0	81	974	**7.87**
robusta	72	1	120	927	0.97	80	0	130	1 029	**4.60**	11	0	13	49	1.10
stricta	12	1	12	229	0.11	9	0	9	18	0.29	2	0	3	3	0.24
Paraserianthes lophantha											2	0	2	2	0.16
Passiflora edulis	5	0	9	45	0.07										
Pennisetum clandestinum	10	4	11	3 354	0.49	2	1	2	1 010	0.54					
Pereskia aculeata	6	1	7	206	0.08										
Pinus															
patula	55	6	148	5 482	**1.73**										
pinaster	4	1	4	230	0.06						2	2	8	2 082	3.72
radiata	8	0	10	86	0.08						6	0	6	202	0.78
Populus															
alba	8	2	10	515	**0.13**										
alba/canescens	128	25	283	18 169	**4.26**	5	0	5	54	0.18					
×*canescens*	198	75	486	51 371	**9.80**	40	8	67	4 537	**4.20**	15	5	31	1 643	**4.89**
Prosopis															
glandulosa	3	0	3	61	0.03	25	4	29	2 395	**2.00**	3	1	3	1 060	1.81
glandulosa/velutina	29	6	54	4 738	0.97	214	55	666	73 664	**56.00**	61	10	156	7 823	**24.00**
velutina	1	0	1	1	0.01	37	5	41	2 788	**2.60**	1	0	1	10	0.09
Prunus persica	211	1	530	6 232	**4.56**	13	0	15	33	0.49	1	0	3	12	0.26
Psidium guajava	29	5	60	2 357	0.72	1	0	1	1	0.08					
Pyracantha															
angustifolia	122	3	256	3 661	**6.07**	9	0	10	19	0.32					
angustifolia/crenulata	33	3	44	1 176	**0.46**										
Ricinus communis	80	3	166	3 149	1.57	13	0	24	208	0.85	20	0	31	313	2.92
Robinia pseudoacacia	83	14	145	8 576	**2.09**	11	0	14	157	0.51					
Rosa rubiginosa	104	12	255	11 201	**3.20**	3	0	3	3	0.10					
Rubus															
cuneifolius	57	31	191	38 602	**6.12**										
fruticosus	15	5	24	3 219	**0.57**						4	2	8	571	1.48
pascuus	1	1	1	200	**0.03**										
sp.	50	21	86	21 188	**3.23**										
×*proteus*	2	1	2	250	**0.05**										
Salix															
babylonica	310	79	1 069	78 092	**17.30**	54	2	90	1 555	3.55	6	0	8	26	0.67
fragilis	71	23	169	15 388	**3.10**	1	0	1	1	0.03					
Salsola kali/tragus	20	1	23	610	0.24	95	26	117	12 309	**9.50**	6	1	7	233	0.90
Schinus molle	54	0	73	360	0.57	75	2	156	3 952	**6.80**	26	0	47	222	**4.06**
Senna didymobotrya	33	4	75	2 100	0.79										
Sesbania punicea	117	22	238	13 269	**3.34**	4	0	4	13	0.13	3	1	8	332	1.13
Solanum															
elaeagnifolium	18	4	21	3 498	0.58	10	6	16	10 202	**5.30**	2	0	2	2	0.16
mauritianum	114	45	530	55 565	**10.60**										
seaforthianum	1	0	1	10	0.01										
Tithonia diversifolia	3	0	3	52	0.03										
Xanthium strumarium	64	2	72	2 364	0.81	9	2	11	1 441	1.03					

Combined taxa e.g. *Ageratum conyzoides/houstonianum* indicate uncertainty of identification. QSp, quarter-degree squares present; QSa, quarter-degree squares abundant; R, records; A, total weighted abundance (see text); Pv, prominence value (bold numbers: highest prominence values which add up to ± upper 80% of summed values—see text).

APPENDIX 4.—Summary of results for all naturalized and casual alien plants in the study area, Savanna Biome, Fynbos Biome, Forest habitats, Grassland Biome, Nama-Karoo Biome, Succulent Karoo Biome and watercourse/wetland habitats

Plant name	QSp	QSa	Study area records	Savanna Biome records	Fynbos Biome records	Forest habitat records	Grassland Biome records	Nama-Karoo Biome records	Succulent Karoo Biome records	Watercourse/ wetland records
Acacia										
baileyana	86		135	20	**39**	1	**75**		1	10
cultriformis #	1		1				1			
cyclops	166	91	1 097	181	**810**	9		1	105	206
dealbata	256	115	1 079	132	23	12	**922**	2	4	542
decurrens	101	31	232	38		4	**194**			30
elata	35	1	60	4	**51**	4	3		2	4
fimbriata	1	1	1	1						
implexa	2		2		2					2
longifolia	94	34	363	**66**	**264**	13	31		2	132
mearnsii	428	251	2 620	**710**	**871**	91	**1 003**		36	953
melanoxylon	134	29	482	73	**298**	85	**109**		2	130
paradoxa	1		2		2					
podalyriifolia	57	2	101	**49**	**27**	1	**25**			6
pycnantha	35	15	135	4	**131**					6
saligna	158	93	1 030	96	**860**	8	2		72	363
viscidula	1		1		1					
Acanthocereus ?*tetragonus*	1	1	1	1						
Acanthospermum										
australe *	1		1				1			
hispidum *	1		1	1						
Acanthus polystachyus var. *pseudopubescens* #	1		1	1						
Acer										
negundo	1		1			1	1			1
? sp.	1		1			1	1			1
Achyranthes aspera *	77	3	85	**44**	5	12	**34**	2		23
Acorus calamus *	1		1				1			1
Acrocarpus fraxinifolius #	1		1			1	1			
Adiantum raddianum #	1		1	1		1				
Agave										
americana										
var. *americana*	431	8	761	**267**	84	2	**219**	**160**	31	118
var. *expansa*	1		1		1					
decipiens #	1		1				1			
sisalana	170	12	293	**251**	10	4	25	3	4	13
sp.	31	1	60	**53**	4		3			12
Ageratina										
adenophora	11	4	26	**11**	**10**	3	5			10
riparia ?#	1		1	1						
Ageratum										
conyzoides	37	8	50	**44**		1	6			32
conyzoides/houstonianum	31	8	49	**45**	1	13	3			24
houstonianum	26	2	31	**26**		8	5			7
Agrimonia cf. *parviflora* #	1		1				1			1
Agrostemma githago *	1		1				1			
Ailanthus altissima	32	2	40	**11**	**6**		**19**	3	1	9
Albizia										
chinensis #	1		1	1						
lebbeck	4	2	5	5						
procera	1		1	1						
Alhagi maurorum	10		11	**8**	**1**			**1**	**1**	3
Alisma plantago-aquatica	8	1	9	2			7			9
Alnus glutinosa	1		1		1					1
Alpinia zerumbet	5		7	2	4	1	1			2
Alternanthera pungens *	4		4	1			3			1
Amaranthus										
hybridus *	3		3				3			1
sp.*	1		1	1						
Ambrosia artemisiifolia *	2		2	1			1			1
Ammi majus *	1		1				1			
Anigozanthos flavidus #	1	1	1		1					
Anredera cordifolia	24	2	25	**17**	3	7	**5**			4
Antigonon leptopus	3		5	5						1
Apium graveolens *	1		1	1						

Combined taxa e.g. *Ageratum conyzoides/houstonianum* indicate uncertainty of identification.

#, casual alien plants: occurring outside cultivation; some species flourishing but less than 10 years of records in SAPIA precludes being categorized as 'naturalized' (Pyšek *et al.* 2004).

*, mainly herbaceous species that are suspected of being under-estimated in this survey.

QDSp, quarter-degree squares present; QDSa, quarter-degree squares abundant.

Bold numbers in biome categories add up to upper 80% or more of total records.

APPENDIX 4.—Summary of results for all naturalized and casual alien plants in the study area, Savanna Biome, Fynbos Biome, Forest habitats, Grassland Biome, Nama-Karoo Biome, Succulent Karoo Biome and watercourse/wetland habitats (cont.)

Plant name	QSp	QSa	Study area records	Savanna Biome records	Fynbos Biome records	Forest habitat records	Grassland Biome reeords	Nama-Karoo Biome reeords	Succulent Karoo Biome reeords	Watereourse/ wetland reeords
Araujia sericifera	36	1	53	**15**	2	4	**35**	1		12
Ardisia crenata	2	1	3	3		2				3
Argemone										
mexicana	27	5	36	**32**	1	1	3			20
ochroleuca subsp. *ochroleuca*	154	20	206	**119**	2	1	**56**	27	2	50
sp.	14	2	15	**7**			1	1	**6**	9
Aristolochia elegans	6	1	8	7		2	**1**			4
Arundo donax	371	82	855	**372**	**172**	3	**188**	77	46	548
Astartea fascicularis #	1		1		1					
Atriplex										
inflata	164	77	213	16	25		4	**107**	**61**	16
muelleri *	1		1					1		
mummularia subsp. *mmmularia*	172	18	333	18	45		6	**181**	**83**	107
semibaccata *	4		5				3	2		1
sp.	10		10					8	2	2
Azolla										
filiculoides	194	92	354	**75**	37	2	**172**	**70**		354
?pinnata var. *imbricata*	3	1	6	6						4
sp.	4		8	8						8
Baeckia sp. #	1		1		1					
Bambusa										
balcooa	32		50	**42**	5	1	3			43
sp. #	1		1	1						
Bambuseae sp.	8		9	7	1		1			3
Banksia										
ericifolia #	1		1		1					
integrifolia #	1	1	1		1					
Bauhinia										
purpurea	1		1	1						
sp.	1		2	2						
variegata	9		11	**11**						1
Begonia cucullata #	1		2	1		1				
Bidens										
bipinnata *	23		23				**23**			7
biternata *	1		1	1						
pilosa *	39	3	65	**17**		1	**47**			12
Billardiera heterophylla #	1		1		1					
Boerhavia erecta *	1		1				1			
Briza maxima *	1		1	1						
Bromus										
catharticus *	2		2				1	1		1
diandrus *	1		1					1		1
pectinatus *	1		1					1		1
Brugmansia ×*candida*	6		7	1	6	1				
Bryophyllum delagoense	4	1	6	6						
?Buddleja madagascariensis #	1		1				1			
Caesalpinia										
decapetala	127	41	413	**239**		25	**174**			153
gilliesii	18		19	**6**			**3**	**8**	2	2
Callistemon										
citrinus #	1		1		1					
glaucus #	1		1	1						
rigidus	1		1	1						
sp.	1		1				1			1
viminalis	1		1		1					1
Calotropis procera #	1		1	1						
Campuloclinium macrocephalum	14	5	25	**16**		1	**9**			3
Canna										
glauca #	1		1	1		1				
indica	26	1	34	**19**	**7**	6	**8**			11
sp.	13		17	**10**	**4**	1	**3**			10
×*generalis*	7		8	8		1				5
Capsella bursa-pastoris *	1		1				1			
Cardiospermum										
grandiflorum	43	12	57	**54**		7	3			29

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Cardiospermum (cont.)										
grandiflorum/halicacabum	16	5	20	**18**		4	2			5
halicacabum	27		35	**34**		5	1			26
Carica papaya	6		6	6						2
Castanea dentata ?#	1		1		1	1				
Castanospermum australe ?#	1		1	1						
Casuarina										
cunninghamiana	9		12	**8**	**2**		**2**			8
cunninghamiana/equisetifolia	42	2	63	**46**	6	1	**11**			23
equisetifolia	24	1	57	**55**		6	2			7
Catharanthus roseus	38	1	53	**49**	1	2	3			11
Cedrus deodara ?#	5		5				5			
Celtis										
australis †	?		?							?
occidentalis †	?		?							?
sinensis †	1		1				1			?
Cenchrus brownii *	1		1	1						
Centranthus ruber ?#	2	2	2		2					
Cereus jamacaru	124	11	193	**169**	6	1	12	6		6
Cestrum										
aurantiacum	8	1	10	**7**	1	6	**2**			2
aurantiacum/laevigatum	7	3	8	5		4	3			1
elegans	2	2	2			2	2			
laevigatum	70	16	167	**138**	9	30	**20**			41
parqui	3		5	4			1			
sp.	1		1	1						1
Chamaesyce										
prostrata *	3		3	1			2			
serpens *	1		1				1			
Chenopodium album *	3		3				3			
Chorizema cordatum #	1		1		1					
Chromolaena odorata	93	64	558	**529**		77	29			220
Cichorium intybus	12	1	16				**14**	2		2
Cinnamomum camphora	10	1	19	**13**	**3**	14	**3**			3
Cirsium										
arvense *	2		2				2			
vulgare	188	20	345	**68**	8		**253**	16		40
Citrus										
limon	1		1	1						
sp.	5		5	1		1	4			2
Coix lacryma-jobi *	1		2	1		1				
Colocasia esculenta	11	3	19	**14**	**5**	1				19
Commelina benghalensis *	9		15	**7**	**3**	5	**3**	2		1
Convolvulus arvensis	23	1	23	**4**	**4**		**11**	**4**		2
Conyza										
bonariensis *	4		4	1			3			1
canadensis *	3		3	2			1			1
primulifolia *	1		1	1						
sp.*	3		3	2			1			2
sumatrensis *	1		1				1			
Coreopsis lanceolata	11		15	**11**			**4**			
Cortaderia										
jubata	7		7		2		5			1
jubata/selloana	23	2	28	**11**		1	**16**		1	4
selloana	54	1	104	**15**	**77**	5	**10**	1	1	21
Corymbia ficifolia ?#	3		3	1	2					
Cosmos bipinnatus *	48	10	122	3			**119**			2
Cotoneaster										
coriaceus ?#	1		1				1			
franchetii	7	1	7	2		1	5			1
glaucophyllus	2		2	1			1			
franchetii/pannosus	19		27	1	2	1	**23**	1		3
pannosus	25		30	2	1		**25**	2		3

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*, mainly herbaceous species that are suspected of being under-estimated in this survey.

†, *Celtis australis* (probably naturalized), *C. occidentalis* (probably naturalized) and *C. sinensis* (naturalized) easily mistaken for indigenous *C. africana* and suspected of being under-estimated in this survey.

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Cotoneaster (cont.)										
sp.	21		23	1	1		**21**			4
Crataegus										
sp. #	2		2				2			
×*lavallei*	4		4			1	4			
Crotalaria agatiflora subsp. *agatiflora*	18		29	**24**			8			1
Cryptomeria japonica #	1		1	1						1
Cryptostegia grandiflora	1		3	3						3
Cuphea ignea #	1		1				1			
Cupressus										
arizonica	47		68		1		**62**	5		1
lusitanica	2		2	1			1			1
sp.	18		24	**3**	1	1	**19**	1		2
Cuscuta										
campestris	82	1	103	**22**	3	2	**73**	5		23
campestris/suaveolens	34		40	**22**	**6**	7	**6**	**6**		5
suaveolens	7		7	2		2	4	1		1
Cydonia oblonga	7		7		3		3	1		1
Cytisus scoparius	10		15	1			**14**			1
Dahlia imperialis ?#	1		2	2						
Datura										
ferox	175	14	201	**87**	3	2	**85**	26		55
innoxia	29	3	36	**30**	1	1	3	2		18
sp.	84	1	110	**41**	1		**65**	2	1	7
stramonium	286	24	373	**131**	19	6	**174**	48	1	73
Delonix regia	5		5	5		2				
Desmanthus virgatus *	1		1	1						
Dracocephalum canariense	1		1		1					
Duranta erecta	32		35	**33**		8	2			8
Dysphania ambrosioides *	2		2	1			1			1
Echinopsis spachiana	57	2	83	**29**	2		**14**	**37**	1	
Echium										
plantagineum	51	6	64	**11**	**31**		**19**	3		4
plantagineum/vulgare			19	2	**17**					1
vulgare	29	2	31	1	**9**		**21**			2
Egeria densa	2		2	2						1
Eichhornia crassipes	87	72	431	**279**	46		**106**			431
Eragrostis pilosa *	1		1	1						
Eriobotrya japonica	3		3	1	2	1				1
Eucalyptus										
camaldulensis	121	22	182	**36**	**81**	3	17	14	**34**	137
cinerea	11		13	2			11			
cladocalyx	37	4	83	2	**71**				10	26
cloeziana	1		1	1						
conferruminata	41	10	117	10	**106**				1	12
diversicolor	49	8	153	1	**148**	28	2		2	32
?exserta	1	1	1		1					1
fastigata	1		1	1						
globulus	12		16		**16**	5				1
gomphocephala	6		11		**11**					
grandis	100	16	190	**111**	1	19	**78**			67
leucoxylon ?#	2		2		2					2
microcorys	1		2		2					
microtheca	1		1					1		1
paniculata	1		1	1						
regnans	6		7		7					3
robusta ?#	1		1	1						1
sideroxylon ?#	1		1				1			
sp.	505	30	1 103	**299**	**147**	17	**614**	27	16	266
tereticornis ?#	1		1				1			1
Eugenia uniflora	2		2	2						
Euphorbia										
heterophylla	3		3	2			1			2
peplus *	1		1				1			
pulcherrima ?#	6		9	9						1

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Fallopia convolvulus *	1		1				1			
Ficus										
carica	18		26	1	**19**		2	1	**3**	13
elastica #	1		1	1						
macrophylla #	1		1	1						
pumila	2		2	1			1			
Flaveria bidentis *	12		12	**11**		1	1			6
Foeniculum vulgare *	9		10	**3**	**5**		1	1		1
Fraxinus										
americana	13		15				**11**	**4**		3
angustifolia	3		3	1	1				1	
sp.	13		14				**11**	**3**		4
Fuchsia sp. #	1		1		1	1				
Genista monspessulana	2		2		2					
Glandularia										
aristigera *	14		27	1			**26**			1
×*hybrida* ?#	1		1				1			
Glebionis coronaria	2	1	4	2	2					
Gleditsia triacanthos	111	1	162	12	1		**136**	12	1	41
Gnaphalium luteoalbum *	1		1	1						1
Gomphrena celosioides *	2		2				2			1
Grevillea										
robusta	53		80	**68**	2	9	10			22
rosmarinifolia #	1		1		1					
sericea #	1		1		1					
Guilleminea densa *	2		2				2			
Hakea										
drupacea	28	2	58	4	**53**				1	
gibbosa	18	3	34	2	**31**				1	
salicifolia	5	1	5		2		3			1
sericea	77	17	230	14	**204**	3	1		11	5
victoriae #	1		1		1					
Harrisia martinii	21	10	33	**32**				1		3
Hedychium										
coccineum	3	1	6	6		2				2
coronarium	14	1	19	**18**		2	1			2
flavescens	5	2	5	3	2	1				2
gardnerianum	12		18	**11**		4	**7**			1
sp.	7	2	8	4	3	2	1			4
Helianthus annuus *	5		8	8						
Heliotropium amplexicaule *	2		3	2			1			
Hibiscus trionum *	2		2				2			
Homalanthus populifolius	2		2		2	2				
Hordeum murinum *	1		1					1		1
Hylocereus undatus	8		8	7	1					
Hypericum										
patulum	1	1	2			1	2			1
perforatum	13	1	19		**16**		3			3
Hypochaeris radicata *	1		1				1			
Ipomoea										
alba	22	1	32	**28**		5	4			19
carnea subsp. *fistulosa*	21	1	36	**35**			1			7
indica	23	3	27	**22**	3	3	2			8
indica/purpurea	74	7	120	**86**	**18**	16	**16**			34
nil	1		1		1					1
purpurea	37	3	46	**23**	**10**	9	**13**			12
sp.	3		3	2			1			1
Jacaranda mimosifolia	195	16	613	**497**		21	**115**	1		105
Jasminum										
humile	2		3				3			
mesnyi ?#	1		1				1			
Jatropha										
gossypiifolia	4		10	**10**						1
sp.	2		2	1			1			

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Juniperus										
pinchotii #	1		1				1			
sp.	4		5				5			3
virginiana	17	2	28	1			**27**			8
Lactuca serriola *	1		1				1			
Lagerstroemia indica	6		7	6			1			
Lantana camara	247	116	2 111	**1 843**	60	63	207		1	289
Lemna										
gibba	3	2	3	2	1					3
sp.	3	1	3	1			1	1		3
Lepidium										
didymum *	1		1	1						
draba	4		4				1	3		
Leptospermum laevigatum	38	15	102	6	**96**	3				10
Leucaena leucocephala	36	3	123	**115**		11	8			43
Ligustrum										
japonicum	7		8	2		2	6			4
lucidum	12	1	16	**5**		2	**11**			6
ovalifolium	3	1	3	2		1	1			1
sinense	8		11	1			**10**			5
sp.	12	2	13	**6**		1	7			7
vulgare	3	1	5	3			2			5
Lilium formosanum	15	3	30	**18**			**12**			
Limonium sinuatum	10	1	10		**5**			**4**	1	2
Linaria										
genistifolia *	1		1				1			
maroccana *	1		3				3			
Litsea glutinosa	8	3	10	**10**		6				5
Lonicera japonica var. *halliana*	5		5	2		1	3			4
Lygodium japonicum #	1		1	1		1				
Lythrum salicaria	1		1		1					1
Macfadyena unguis-cati	22	9	52	**47**		13	5			14
Maireana brevifolia ?#	1		1	1						
Malus pumila var. *paradisiaca* ?#	5		7		2		5			1
Malva										
dendromorpha	16	1	24	1	**19**			1	**3**	3
linnaei *	1		1		1					
parviflora *	2		2		1		1			
Malvastrum coromandelianum *	2		2	1			1			
Mangifera indica	12	1	30	**30**		1				16
Manihot										
esculenta	8		10	**9**			1			1
grahamii #	6		7	7		1				1
Medicago sativa *	2		2	1			1			
Melaleuca										
hypericifolia	1		2		2					
wilsonii #	1		1		1					
Melia azedarach	551	65	2 119	**1 394**	82	29	**588**	49	6	674
Melilotus alba *	15		26	2			**24**			2
Metasequioa glyptostroboides #	1		1				1			1
Metrosideros excelsa	2	1	5		5					3
Mimosa										
pigra	6	1	8	7			1			7
pudica var. *hispida* *	2		2	2						
Mirabilis jalapa *	7		7	3			4			
Momordica charantia *	1		1	1						
Monstera deliciosa #	1		1	1						1
Montanoa hibiscifolia	24	2	46	**41**		6	5			13
Moringa oleifera #	2		2	2						
Morus alba	129	8	304	**192**	2	10	**109**	1		164
Musa sp. #	8		15	**15**						10
Myoporum tenuifolium subsp. *montanum*	30		49	2	**44**	1			3	4

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Myriophyllum										
aquaticum	48	10	81	**39**	**17**		**25**			81
spicatum	20		23	**11**	2		**9**	1		23
Nassella										
tenuissima	1		2				2			1
trichotoma	12	3	16	**12**	1		**10**	1	1	
Nasturtium officinale	50	1	64	**19**	4	1	**38**	3		64
Nephrolepis exaltata	13	1	19	**12**	**6**	13	1			2
Nerium oleander	23	2	46	**16**	**21**		1	4	4	36
Nicandra physalodes *	1		1	1						
Nicotiana										
glauca	383	14	957	**274**	**168**	1	72	**206**	**237**	441
tabacum ?#	3		3	3						3
Nymphaea										
×*marliacea*	1		1				1			1
mexicana	2	2	4	1			3			4
Oenothera										
biennis *	19	1	19	**5**			**13**	1		10
glazioviana *	1	1	1				1			
indecora *	1		1				1			
jamesii *	15	2	17	**7**	1		**9**			10
laciniata *	1		1				1			
rosea *	4		4				4			1
sp.	4		4				4			
tetraptera *	1		1				1			
Olyra latifolia *	1		1	1		1				
Opuntia										
aurantiaca	61	3	84	**50**			**28**	4	2	4
engelmannii (= O. lindheimeri)	10	3	15	**6**			2	**7**		1
exaltata	6		6	2			3			
ficus-indica	861	57	2 445	**1 159**	267	8	**570**	**368**	81	129
fulgida	11	2	12	**7**			2	**3**		
humifusa	25	3	32	**18**	2		**10**	2		2
?humifusa/engelmannii	48	4	49	**23**			**17**	9		1
imbricata	131	15	151	**49**	8	3	**48**	**43**	3	6
microdasys	9		10	**4**	**3**			**3**		
monacantha	48	1	114	**90**	**22**	5	2			17
robusta	225	2	337	**61**	13		**120**	**130**	13	4
sp.	37		39	**21**	5		**10**	3		2
spinulifera ?#	1		1	1						
stricta	106	14	193	**168**	1		12	9	3	4
?stricta × *humifusa*	1		1	1						
Orobanche minor	4		5	2	3					
Oxalis corniculata *	4		4	1			3			1
Pandanus sp. #	1		1	1						1
Paraserianthes lophantha	54	9	286	10	**274**	7			2	82
Parkinsonia aculeata	15		18	12				6		4
Parthenium hysterophorus	15	3	29	**29**						8
Parthenocissus quinquefolia #	1		1	1						
Paspalum										
dilatatum *	6		6	1	2	2	3			1
quadrifarium *	1		1				1			1
urvillei *	1		1	1						
Passiflora										
caerulea	12		20	**10**	**9**	2	1			12
edulis	32		55	**40**	6	19	**9**			12
sp.	19	1	22	**13**	**6**	11	3			**7**
suberosa	6		7	6		2	1			
subpeltata	21	1	26	**22**		3	4			3
tripartita var. *mollissima*	4		4		3	1	1			1
Pennisetum										
clandestinum	48	12	56	**12**	**28**	3	**14**	2		6
purpureum	40	6	87	**82**			5			30
setaceum	66	**17**	84	**39**	**20**		8	**17**		2
setaceum/villosum	15	1	15	**4**	**4**		**6**		1	1
sp.	11	4	15				11			
villosum	22	5	26	2	3		14	7		1

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Pereskia aculeata	44	8	102	**91**	4	39	7			8
Persea americana #	2		2				2			1
Persicaria lapathifolia *	1		1				1			1
Phoenix										
canariensis	3		3		2				1	3
dactylifera	4		4		3			1		4
Phormium tenax #	2		2		2					2
Physalis										
peruviana *	3		3	2			1			
viscosa *	3		3	1			2			2
Phytolacca										
dioica	30		38	**17**	**20**	1			1	15
icosandra *	4		5		5					1
Pinus										
canariensis	6	1	9	2	7					
elliottii	34	6	59	**35**		3	**23**	1		7
elliottii/taeda	30	1	59	**41**		2	**18**			9
halepensis	85	3	136	**45**	**53**		**33**	4	1	9
patula	85	13	238	**90**		18	**148**			59
pinaster	85	44	401	**34**	**355**	29	4		8	36
pinea	18		35	1	**30**		4			1
radiata	70	15	206	4	**186**	20	10		6	16
roxburghii	2		2				2			
sp.	126	14	169	**47**	**47**	3	**70**	3	2	18
taeda	7		11	**6**			**5**			3
Pistia stratiotes	24	6	63	**60**	2		1			63
Pittosporum undulatum	3		7		7	1				3
Pityrogramma calomelanos *	1		1	1		1				
Plantago										
lanceolata *	4		4				4			1
major *	2		2	1			1			
virginica *	1		1				1			
Platanus sp. #	1		1		1					
Plectranthus comosus	19		22	**8**	**11**	1	**3**			2
Polygonum aviculare *	1		1				1			1
Polypogon monspeliensis *	1		1	1						
Pomaderris kumeraho #	1		1		1					
Pontederia cordata	2		2	2						2
Populus										
alba	15	2	22	**11**	1		**10**			17
alba/×*canescens*	185	47	460	**171**	1	8	**283**	5		336
deltoides	100	6	169	**37**	3	1	**114**	15		117
nigra var. *italica*	90		120	2	7		**94**	**17**		100
×*canescens*	371	130	939	76	**279**	4	**486**	67	31	823
Portulaca oleracea *	2		2	1			1			
Prosopis										
glandulosa var. *torreyana*	40	10	50	**13**	2		3	**29**	3	13
glandulosa/velutina	390	78	1 108	**168**	63		54	**666**	**156**	443
velutina	48	6	53	**7**	3		1	**41**	1	18
Prunus										
armeniaca	32		44	1	**6**		**34**	2	1	9
persica	319	1	728	**115**	65	1	**530**	15	3	148
serotina	1		1				1			1
Psidium										
cattleianum	5		8	7		4	1			1
guajava	160	50	732	**662**	9	25	60		1	179
guineense	2		2	2		1				
sp.	36	7	47	**44**		6	3			12
×*durbanensis*	2		3	3		2				
Pterocarya stenoptera #	1		1	1		1				1
Pueraria montana var. *lobata*	3		3	2			1			2
Punica granatum	8		11	1	**4**		**3**	**3**		2
Pyracantha										
angustifolia	142	3	285	13	6	2	**256**	10		78
angustifolia/crenulata	40	3	51	5	2	1	**44**			5

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Plant name	QSp	QSa	Study area records	Savanna Biome records	Fynbos Biome records	Forest habitat records	Grassland Biome records	Nama-Karoo Biome records	Succulent Karoo Biome records	Watercourse/ wetland records
Pyracantha (cont.)										
coccinea	6		7				7			2
crenulata	22		31	2		1	**29**			2
Pyrus sp. ?#	5		5		4		1			1
Quercus										
canariensis ?#	1		1		1					
cerris ?#	2		2		2					
palustris	5		5		2		3			1
robur	50	2	88	3	**57**	5	**26**		2	53
sp.	4		6	1	4		1			3
suber ?#	1		1		1					
Richardia										
brasiliensis *	1		1	1						1
humistrata *	1		1				1			
Ricinus communis	456	56	1 701	**1 230**	**250**	30	**166**	24	31	582
Rivina humilis	7	1	10	10		4				1
Robinia pseudoacacia	110	14	178	13	6	1	**145**	14		66
Rosa										
multiflora	5		5	3			2			1
? ×odorata #	1		1	1						1
rubiginosa	119	12	276	12	6	2	**255**	3		59
sp. #	3		3	2			1			
Rubus										
cuneifolius	75	35	236	45		6	**191**			71
flagellaris	3		4		4					1
fruticosus	89	32	244	**24**	**188**	14	**24**		8	71
?pascuus	3	2	3	2			1			
phoenicolasius	4		4			1	4			
rosifolius	14	1	14	**9**	2	3	**3**			3
sp.	86	30	179	**88**	5	12	**86**			54
×proteus	4	3	4	2			2			3
Rumex										
acetosella subsp. *pyrenaicus* *	1		1				1			1
crispus *	2		2	1			1			
usambarensis	4	1	4	3			1			
Saccharum officinarum	15	1	26	25			1			8
Salix										
babylonica	475	89	1 381	**140**	74	6	**1 069**	90	8	1 323
caprea	9		12				12			10
fragilis	75	24	176	5	1		**169**	1		175
Salsola kali/tragus	155	31	187	**27**	13		**23**	**117**	7	2
Salvinia molesta	29	7	44	**25**	**14**		5			44
Sambucus										
canadensis	3	1	3	1			2			3
sp.	10		11	2			**9**			6
Schefflera actinophylla #	1		1	1						
Schinus										
molle	231	2	407	**82**	**49**	1	**73**	**156**	**47**	136
terebinthifolius	30	2	90	**85**	2	9	3			54
Schizolobium parahyba var. *parahyba* #	1		1	1						
Schkuhria pinnata *	4		4	1			3			1
Senna										
bicapsularis	16	1	45	**45**						31
corymbosa	4		4	2			2			1
didymobotrya	139	29	339	**261**	3	15	**75**			115
hirsuta	9		10	10						1
multiglandulosa	11	1	12	**6**	**4**	1	2			3
obtusifolia	4		5	5						3
occidentalis	56	4	75	**74**		1	1			27
pendula var. *glabrata*	19	2	21	**19**		2	2			6
septemtrionalis	63		102	**84**	1	8	17			31
sp.	16		23	**12**	**6**	2	**5**			12
Sesbania										
bispinosa *	1		1				1			1
punicea	323	68	830	**405**	**175**	8	**238**	4	8	500

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Sigesbeckia orientalis *	1		1	1						
Silybum marianum *	7		9	7			2			
Sisymbrium orientale *	1		1				1			
Sisyrinchium sp. *	2		2		2	2				
Solanum										
betaceum	4		5		4	3	1			
capsicoides *	1		1	1						
chrysotrichum	21		21	**21**						12
elaeagnifolium	51	11	60	**18**	3		**21**	**16**	2	4
mauritianum	265	99	1 364	**748**	86	97	**530**			419
pseudocapsicum *	6		10	1	**8**	7	1			5
seaforthianum	30	3	77	**75**	1	31	1			50
sisymbriifolium	40	3	51	**18**	3	1	**30**			5
sp.	4		6	5		2	1			1
torvum *	1		1	1						
Sonchus oleraceus *	3		3	1			2			
Sophora cf. *davidii* #	1		1				1			1
Sorghum halepense	41	2	46	**26**	3	2	**11**	6		17
Spartium junceum	20	3	43	4	**35**		3		1	2
Spathodea campanulata	3		4	4						
Sphagneticola trilobata *	1		2	2						1
Spiraea cantoniensis #	1		1				1			
Stellaria media *	1		1				1			
Stenocarpus sinuatus ?#	1	1	1		1					
Styphnolobium japonicum ?#	1		1				1			1
Symphyotrichum squamatum *	1		1				1			
Syncarpia glomulifera	2		2	2						
Syzygium										
cumini	9	1	14	**13**		2	1			4
jambos	3		3	2	1					2
paniculatum	3		3	3						
Tabebuia chrysotricha ?#	1		1	1						
Tagetes minuta *	47		78	11		1	**66**	1		16
Tamarix										
chinensis	4		4				1	3		2
ramosissima	7		8	1	3			4		8
sp.	85	4	110	10	**16**		8	**58**	**18**	85
Taraxacum officinale *	1		1				1			
Tecoma stans	57	4	99	**95**		2	4			17
Tephrocactus										
?aoracanthus	1		1					1		1
articulatus	1		1					1		
sp.	1		1					1		
Thevetia peruviana	15		23	**23**						6
Tipuana tipu	24	1	42	**33**			**9**			3
Tithonia										
diversifolia	49	5	123	**120**		10	3			33
diversifolia/rotundifolia	3	1	3	3						
rotundifolia	19	5	28	**22**		2	**6**			7
Toona ciliata	23	1	54	**51**		7	3			10
Torilis arvensis *	1		1	1						
Toxicodendron succedaneum	12	1	14	**12**		3	2			3
Tragopogon dubius *	1		1				1			
Tridax procumbens *	1		1	1						1
Triplaris americana ?#	1		1	1						
Triticum aestivum *	1		1				1			
Tropaeolum majus *	3		3	2	1	1				1
Ulex europaeus	9		14	**2**			**11**	1		3
Ulmus										
parvifolia	2		2				2			1
procera #	1		1				1			1
sp. #	4		4				3	1		1
Verbena										
bonariensis *	58	4	115	22			**93**			13
brasiliensis/bonariensis	2		4	3			1			
brasiliensis *	2		2	2						

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Verbena (cont.)										
officinalis *	2		2				2			1
rigida var. *rigida* *	1		1	1						
Verbesina encelioides *	18		21	**14**				**7**		5
Vinca major *	1		1		1					
Vitis sp. #	6		12		**11**		1			
Washingtonia sp. ?#	3		3	2					1	3
Wigandia urens var. *caracasana* #	3		4	2	2					
Wisteria floribunda #	1		1				1			
Xanthium										
sp.	6		7	5				2	1	7
spinosum	83	6	104	**30**	3		**62**	8		27
strumarium	149	21	212	**126**	3	4	**72**	11		95
Yucca aloifolia	20		22	**8**	**2**		**9**	**2**		5
Zinnia peruviana *	4		6	5		1	1			

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APPENDIX 5.—Species checklist

The following 601naturalized and casual alien (#) plant species were catalogued in the SAPIA database up to May 2006. Accepted names in roman type. Synonyms in italics. *, taxa added to SAPIA after 2000; †, taxa recorded only in Zimbabwe and Malawi. PRE, species records from the Pretoria National Herbarium

Acacia
baileyana *F.Muell.*, Fabaceae, Bailey's wattle
cultriformis *A.Cunn. ex G.Don*, Fabaceae, knife-leaved wattle #
cyclops *A.Cunn. ex G.Don*, Fabaceae, red eye
dealbata *Link.*, Fabaceae, silver wattle
decurrens *Willd.*, Fabaceae, green wattle
elata *A.Cunn. ex Benth.* (*A. terminalis* (Salisb.) J.F.Macb. misapplied in South Africa), Fabaceae, peppertree wattle
fimbriata *A.Cunn. ex G.Don*, Fabaceae, fringed wattle
implexa *Benth.*, Fabaceae, hickory wattle
longifolia *(Andrews) Willd.*, Fabaceae, long-leaved wattle
mearnsii *De Wild.*, Fabaceae, black wattle
melanoxylon *R.Br.*, Fabaceae, Australian blackwood
paradoxa *DC.* (= *A. armata* R.Br.), Fabaceae, kangaroo thorn
podalyriifolia *A.Cunn. ex G.Don*, Fabaceae, pearl acacia
pycnantha *Benth.*, Fabaceae, golden wattle
saligna *(Labill.) H.L.Wendl.* (= *A. cyanophylla* Lindl.), Fabaceae, Port Jackson willow
stricta *(Andrews) Willd.*, Fabaceae, hop wattle ?#, *2004
viscidula *Benth.*, Fabaceae, sticky wattle

Acanthocereus ?tetragonus *(L.) Hummelinck*, Cactaceae, barbed-wire cactus

Acanthospermum
australe *(Loefl.) Kuntze* (= *A. brasilum* Schrank), Asteraceae, eight-seeded prostrate starbur
hispidum *DC.*, Asteraceae, upright starbur

Acanthus polystachyus *Delile* var. pseudopubescens *Cufod.* (= *A. pubescens* Engl.), Acanthaceae, bear's breeches #

Acer
buergerianum *Miq.*, Aceraceae, Chinese maple, *2003 #
negundo *L.* (= *A. californicum* D.Dietr.), Aceraceae, ash-leaved maple
? sp., Aceraceae, ?red-leafed maple

Achyranthes aspera *L.* (= *A. argentea* Lam.), Amaranthaceae, burweed
Acorus calamus *L.*, Acoraceae, calamus
Acrocarpus fraxinifolius *Wight ex Arn.*, Fabaceae, shingle tree #
Adiantum raddianum *C.Presl*, Adiantaceae, maidenhair fern #

Agave
americana *L*
var. americana, Agavaceae, American agave
var. expansa *(Jacobi) Gentry* (= *A. expansa* Jacobi), Agavaceae, spreading century plant
decipiens *Baker* (= *A. laxifolia* Baker), Agavaceae, false sisal #
sisalana *Perrine,* Agavaceae, sisal
sp., Agavaceae

Ageratina
adenophora *(Spreng.) R.M.King & H.Rob.* (= *Eupatorium adenophorum* Spreng.), Asteraceae, crofton weed
riparia *(Regel) R.M.King & H.Rob.* (= *Eupatorium riparium* Regel), Asteraceae, creeping crofton weed ?#

Ageratum
conyzoides *L.*, Asteraceae, invading ageratum
houstonianum *Mill.*, Asteraceae, Mexican ageratum

Agrimonia cf. parviflora *Aiton*, Rosaceae, agrimony #
Agrostemma githago *L.*, Caryophyllaceae, corn cockle
Ailanthus altissima *(Mill.) Swingle*, Simaroubaceae, tree-of-heaven

Albizia
chinensis *(Osbeck) Merr.* (= *A. stipulata* (DC.) Boivin), Fabaceae, Chinese false-thorn #
lebbeck *(L.) Benth.*, Fabaceae, lebbeck tree
procera *(Roxb.) Benth.*, Fabaceae, false lebbeck

Alhagi maurorum *Medik.* (= *A. camelorum* Fisch.), Fabaceae, camelthorn bush
Alisma plantago-aquatica *L.*, Alismataceae, water plantain
Alnus glutinosa *(L.) Gaertn.* (= *A. barbata* C.A.Mey.), Betulaceae, black elder
Alpinia zerumbet *(Pers.) B.L.Burtt & R.M.Sm.* (= *A. speciosa* (J.C.Wendl.) K.Schum.), Zingiberaceae, shell ginger
Alternanthera pungens *Kunth* (= *A. repens* (L.) Link.), Amaranthaceae, khaki bur weed

Amaranthus
hybridus *L.*, Amaranthaceae, pigweed
sp., Amaranthaceae

Ambrosia artemisiifolia *L.*, Asteraceae, annual ragweed
Ammi majus *L.* (= *A. glaucifolium* L.), Apiaceae, bishop's weed
Anigozanthos flavidus *DC.*, Haemodoraceae, yellow kangaroo paw #
Anredera cordifolia *(Ten.) Steenis*, (*A. baselloides* (Kunth) Baill. misapplied in South Africa), Basellaceae, bridal wreath

APPENDIX 5.—Species checklist (cont.)

Antigonon leptopus *Hook. & Arn.*, Polygonaceae, coral creeper
Apium graveolens *L.*, Apiaceae, wild celery

Araucaria
sp., Araucariaceae, monkey puzzle tree, *2003 #
bidwillii *Hook.*, Araucariaceae, bunya-bunya, *2005 #

Araujia sericifera *Brot.*, Asclepiadaceae, moth catcher

Ardisia
crenata *Sims* (*A. crispa* (Thunb.) A.DC. misapplied in South Africa), Myrsinaceae, coralberry tree
elliptica *Thunb.* (= *A. humilis* Vahl), Myrsinaceae, shoebutton ardisia, *2005 #

Argemone
mexicana *L.*, Papaveraceae, yellow-flowered Mexican poppy
ochroleuca *Sweet* subsp. ochroleuca, Papaveraceae, white-flowered Mexican poppy
sp., Papaveraceae

Aristolochia elegans *Mast.*, Aristolochiaceae, calico flower
Arundo donax *L.*, Poaceae, giant reed
Astartea fascicularis *(Labill.) DC.*, Myrtaceae #

Atriplex
inflata *F.Muell.* (= *A. lindleyi* Moq. subsp. *inflata* (F.Muell.) Paul G.Wilson), Chenopodiaceae, sponge-fruit saltbush
muelleri *Benth.*, Chenopodiaceae, Mueller's saltbush
nummularia *Lindl.* subsp. nummularia, Chenopodiaceae, old-man saltbush
semibaccata *R.Br.*, Chenopodiaceae, Australian saltbush
sp., Chenopodiaceae

Azolla
filiculoides *Lam.*, Azollaceae, red water fern
?pinnata *R.Br.* subsp. asiatica *R.M.K Saunders & K.Fowler* (= *A. imbricata* (Roxb. ex Griff.) Nakai), Azollaceae, mosquito fern
sp., Azollaceae

Baeckia sp., Myrtaceae #

Bambusa
balcooa *Roxb.*, Poaceae, common bamboo
sp. with tall yellow stems and green leaves, Poaceae, bamboo

Bambuseae sp., Poaceae, bamboo

Banksia
ericifolia *L.f.*, Proteaceae, heath banksia #
integrifolia *L.f.*, Proteaceae, coast banksia #

Bauhinia
purpurea *L.*, Fabaceae, butterfly orchid tree
sp., Fabaceae
variegata *L.*, Fabaceae, orchid tree

Begonia cucullata *Willd.* (= *B. semperflorens* Link & Otto), Begoniaceae, begonia #

Bidens
bipinnata *L.*, Asteraceae, Spanish black jack
biternata *(Lour.) Merr. & Sherff*, Asteraceae, five-leaved black jack
pilosa *L.*, Asteraceae, black jack

Billardiera heterophylla *(Lindl.) L.W.Cayzer & Crisp* (= *Sollya heterophylla* Lindl.), Pittosporaceae, bluebell creeper #

Boerhavia erecta *L.*, Nyctaginaceae, erect boerhavia
Bougainvillea glabra *Choisy*, Nyctaginaceae, bougainvillea, *2004 #
Brachychiton populneus *(Schott & Endl.) R.Br.*, Sterculiaceae, kurrajong, *2006 #
Briza maxima *L.* (= *B. major* K.Presl), Poaceae, quaking grass

Bromus
catharticus *Vahl* (= *B. unioloides* Kunth, *B. willdenowii* Kunth), Poaceae, rescue grass
diandrus *Roth*, Poaceae, ripgut brome
pectinatus *Thunb.* (= *B. adoensis* Hochst. ex Steud.), Poaceae, Japanese brome

Brugmansia ×candida *Pers.*, (= *Datura candida* (Pers.) Saff.), Solanaceae, moonflower bush

Bryophyllum
delagoense *(Eckl. & Zeyh.) Schinz* (= *Kalanchoe tubiflora* (Harv.) Raym.-Hamet), Crassulaceae, chandelier plant
pinnatum *(Lam.) Oken* (= *Kalanchoe pinnata* (Lam.) Pers.), Crassulaceae, green mother of millions, *2005 ?naturalized
proliferum *Bowie ex Hook.* (= *Kalanchoe prolifera* (Bowie ex Hook.) Raym.-Hamet, Crassulaceae, *2005 ?naturalized

Buddleja
davidii *Franch.*, Buddlejaceae, Chinese sagewood, *2004 ?naturalized
?Buddleja madagascariensis *Lam.*, Buddlejaceae, Madagascar sagewood #

Caesalpinia
decapetala *(Roth) Alston* (= *C. sepiaria* Roxb.), Fabaceae, Mauritius thorn
gilliesii *(Hook.) D.Dietr.*, Fabaceae, bird-of-paradise
pulcherrima *(L.) Sw.*, Fabaceae, pride of barbados, *2004 #

Callisia repens *(Jacq.) L.*, Commelinaceae, creeping inch plant, *2006 #

Callistemon
citrinus *(Curtis) Skeels*, Myrtaceae, crimson bottlebrush #
glaucus *(Curtis) Sweet* (= *C. speciosus* auct.), Myrtaceae, Albany bottlebrush #
rigidus *R.Br.*, Myrtaceae, stiff bottlebrush
sp., Myrtaceae
viminalis *(Sol. ex Gaertn.) G.Don*, Myrtaceae, weeping bottlebrush

Calotropis procera *(Aiton) W.T.Aiton* (= *Asclepias procera* Aiton), Asclepiadaceae, madar #
Campuloclinium macrocephalum *(Less.) DC.* (= *Eupatorium macrocephalum* Less.), Asteraceae, pom pom weed

Canna
glauca *L.*, Cannaceae, yellow-flowered glaucous canna #
indica *L.* (= *C. edulis* Ker Gawl.), Cannaceae, Indian canna
sp., Cannaceae
×generalis *L.H.Bailey*, Cannaceae, garden canna

Capsella bursa-pastoris *(L.) Medik.*, Brassicaceae, shepherd's purse

Cardiospermum
grandiflorum *Sw.*, Sapindaceae, balloon vine
halicacabum *L.*, Sapindaceae, heart pea

Carica papaya *L.* (= *Papaya carica* Gaertn.), Caricaceae, pawpaw
Castanea dentata *(Marshall) Borkh.*, Fagaceae, American chestnut ?#
Castanospermum australe *A.Cunn. & C.Fraser ex Hook.*, Fabaceae, Australian chestnut ?naturalized

Casuarina
cunninghamiana *Miq.*, Casuarinaceae, beefwood
equisetifolia *L.*, Casuarinaceae, horsetail tree

Catharanthus roseus *(L.) G.Don* (= *Lochnera rosea* (L.) Rchb., *Vinca rosea* L.), Apocynaceae, Madagascar periwinkle
Cedrus deodara *(Roxb. ex D.Don) G.Don*, Pinaceae, deodar ?#

Celtis
australis *L.*, Ulmaceae, European hackberry ?naturalized
occidentalis *L.*, Ulmaceae, common hackberry ?naturalized
sinensis *Pers.*, Ulmaceae, Chinese nettle tree

Cenchrus brownii *Roem. & Schult.* (= *C. viridis* Spreng.), Poaceae, fine burgrass
Centranthus ruber *(L.) DC.*, Valerianaceae, red valerian ?naturalized
Cereus jamacaru *DC.* (*C. peruvianus* (L.) Mill. misapplied in South Africa), Cactaceae, queen of the night

Cestrum
aurantiacum *Lindl.*, Solanaceae, yellow or orange cestrum
elegans *(Brongn.) Schltdl.* (= *C. purpureum* (Lindl.) Standl.), Solanaceae, crimson cestrum
laevigatum *Schltdl.*, Solanaceae, inkberry
parqui *L'Hér.*, Solanaceae, Chilean cestrum
sp., Solanaceae

Chamaesyce
prostrata *(Aiton) Small* (= *Euphorbia prostrata* Aiton), Euphorbiaceae, hairy creeping milkweed
serpens *(Kunth) Small* (= *Euphorbia serpens* Kunth), Euphorbiaceae, milkweed

Chenopodium album *L.*, Chenopodiaceae, white goosefoot
Chondrilla juncea *L.*, Asteraceae, skeletonweed, *2003 #
Chorizema cordatum *Lindl.*, Fabaceae, Australian flame pea #
Chromolaena odorata *(L.) R.M.King & H.Rob.* (= *Eupatorium odoratum* L.), Asteraceae, triffid weed
Cichorium intybus *L.*, Asteraceae, chicory
Cinnamomum camphora *(L.) J.Presl*, Lauraceae, camphor tree

Cirsium
arvense *(L.) Scop.*, Asteraceae, Canada thistle
vulgare *(Savi) Ten.* (= *C. lanceolatum* (L.) Scop.), Asteraceae, spear thistle

Cissus antarctica *Vent.*, Vitaceae, kangaroo vine, *2002 #

Citrus
limon *(L.) Burm.f.* (= *C. limonum* Risso), Rutaceae, lemon
sp., Rutaceae

Clusia rosea *Jacq.*, Clusiaceae, balsam fig/apple, *2003 #
Coffea arabica *L.*, Rubiaceae, arabica coffee, †Zimbabwe # abundant locally
Coix lacryma-jobi *L.*, Poaceae, Job's tears
Colocasia esculenta *(L.) Schott*, Araceae, elephant's ear

APPENDIX 5.—Species checklist (cont.)

Commelina benghalensis *L.*, Commelinaceae, Benghal wandering Jew
Convolvulus arvensis *L.*, Convolvulaceae, field bindweed

Conyza
- bonariensis *(L.) Cronquist* (= *Erigeron bonariensis* L.), Asteraceae, flax-leaf fleabane
- canadensis *(L.) Cronquist* (= *Erigeron canadensis* L.), Asteraceae, horseweed fleabane
- primulifolia *(Lam.) Cuatrec. & Lourteig* (= *C. chilensis* Spreng.), Asteraceae, Chilean fleabane
- sp., Asteraceae
- sumatrensis *(Retz.) E.Walker* (= *C. albida* Willd. ex Spreng.), Asteraceae, tall fleabane

Coreopsis lanceolata *L.*, Asteraceae, tickseed

Cortaderia
- jubata *(Lemoine ex Carrière) Stapf*, Poaceae, purple Pampas grass
- selloana *(Schult.) Asch. & Graebn.*, Poaceae, common Pampas grass

Corymbia ficifolia *(F.Muell.) K.D.Hill & L.A.S.Johnson* (= *Eucalyptus ficifolia* F.Muell.), Myrtaceae, red flowering gum #

Cosmos bipinnatus *Cav.* (= *Bidens formosa* (Bonato) Sch. Bip.), Asteraceae, cosmos

Cotoneaster
- coriaceus *Franch.* (= *C. lacteus* W.W.Sm.), Rosaceae #
- franchetii *Bois*, Rosaceae, orange cotoneaster
- glaucophyllus *Franch.*, Rosaceae, late cotoneaster
- pannosus *Franch.*, Rosaceae, silver-leaf cotoneaster
- sp., Rosaceae

Crataegus
- sp., Rosaceae #
- ×lavallei *Hérincq* (= *C. carrierei* Vauvel ex Carriére), Rosaceae, Lavallee thorn

Crotalaria agatiflora *Schweinf.* subsp. agatiflora, Fabaceae, canary-bird bush
Cryptomeria japonica *(L.f.) D.Don*, Cupressaceae, Japanese cedar #
Cryptostegia grandiflora *R.Br.*, Asclepiadaceae, rubber vine
Cuphea ignea *A.DC.*, Lythraceae, cigarette bush #

Cupressus
- arizonica *Greene* (= *C. glabra* Sudw.), Cupressaceae, Arizona cypress
- lusitanica *Mill.* (= *C. lindleyi* Klotzsch ex Endl.), Cupressaceae, Mexican cypress
- sp., Cupressaceae

Cuscuta
- campestris *Yunck.*, Convolvulaceae, common dodder
- suaveolens *Ser.*, Convolvulaceae, lucerne dodder

Cyathea cooperi *(Hook. ex F.Muell.) Domin* (= *Sphaeropteris cooperi* (Hook. ex F. Muell.) R.M.Tryon), Cyatheaceae, Australian tree fern, *2005 #

Cydonia oblonga *Mill.*(= *C. vulgaris* Pers.), Rosaceae, quince
Cytisus scoparius *(L.) Link* (= *Genista scoparia* (L.) Lam.), Fabaceae, Scotch broom
Dahlia spp., Asteraceae, garden dahlias ?naturalized

Datura
- ferox *L.*, Solanaceae, large thorn apple
- innoxia *Mill.* (*D. metel* L. misapplied in South Africa), Solanaceae, downy thorn apple
- sp., Solanaceae
- stramonium *L.*, Solanaceae, common thorn apple

Delonix regia *(Bojer ex Hook.) Raf.* (= *Poinciana regia* Bojer ex Hook.), Fabaceae, flamboyant
Desmanthus virgatus *(L.) Willd.* (= *D. depressus* Humb. & Bonpl. ex Willd.), Fabaceae, ground tamarind
Desmodium uncinatum *(Jacq.) DC.*, Fabaceae, silverleaf desmodium, †Zimbabwe # abundant locally
Dracocephalum canariense *L.* (= *Cedronella canariensis* (L.) Webb & Berthel.), Lamiaceae, hortela de burro
Duranta erecta *L.* (= *D. repens* L., *D. plumieri* Jacq.), Verbenaceae, forget-me-not-tree
Dysphania ambrosioides *(L.) Mosyakin & Clemants* (= *Chenopodium ambrosioides* L.), Chenopodiaceae, American goosefoot
Echinopsis spachiana *(Lem.) Friedrich & G.D.Rowley* (= *Trichocereus spachianus* (Lem.) Riccob.), Cactaceae, torch cactus

Echium
- plantagineum *L.* (= *E. lycopsis* L.), Boraginaceae, Patterson's curse
- vulgare *L.*, Boraginaceae, blue echium

Egeria densa *Planch.* (= *Elodea densa* (Planch.) Casp.), Hydrocharitaceae, dense water weed
Eichhornia crassipes *(Mart.) Solms*, Pontederiaceae, water hyacinth
Eragrostis pilosa *(L.) P.Beauv.*, Poaceae, Indian love grass
Eriobotrya japonica *(Thunb.) Lindl.*, Rosaceae, loquat

Eucalyptus
- camaldulensis *Dehnh.*, Myrtaceae, red river gum
- cinerea *F.Muell. ex Benth.*, Myrtaceae, florist's gum
- cladocalyx *F.Muell.*, Myrtaceae, sugar gum
- cloeziana *F.Muell.*, Myrtaceae, iron gum
- conferruminata *D.J.Carr & S.G.M.Carr* (*E. lehmannii* (Schauer) Benth. misapplied in South Africa), Myrtaceae, bald island marlock or 'spider gum'
- diversicolor *F.Muell.*, Myrtaceae, karri
- ?exserta *F.Muell.*, Myrtaceae, Queensland peppermint
- fastigata *H.Deane & Maiden*, Myrtaceae, cut-tail gum
- globulus *Labill.*, Myrtaceae, blue gum
- gomphocephala *DC.*, Myrtaceae, tuart
- grandis *W.Hill ex Maiden* (*E. saligna* Sm. misapplied in South Africa), Myrtaceae, saligna gum
- leucoxylon *F.Muell.*, Myrtaceae, white ironbark ?#
- microcorys *F.Muell.*, Myrtaceae, tallow gum
- microtheca *F.Muell.*, Myrtaceae, coolabah
- paniculata *Sm.*, Myrtaceae, grey ironbark
- regnans *F.Muell.*, Myrtaceae, mountain ash
- robusta *Sm.*, Myrtaceae, swamp mahogany gum ?#
- sideroxylon *A.Cunn ex Woolls*, Myrtaceae, black ironbark ?#
- sp., Myrtaceae
- tereticornis *Sm.*, Myrtaceae, forest red gum ?#

Eugenia uniflora *L.*, Myrtaceae, pitanga

Euphorbia
- heterophylla *L.* (= *E. geniculata* Ortega), Euphorbiaceae, annual poinsettia
- leucocephala *Lotsy*, Euphorbiaceae, white poinsettia, *2005 ?naturalized
- peplus *L.*, Euphorbiaceae, stinging milkweed
- pulcherrima *Willd. ex Klotzsch* (= *Poinsettia pulcherrima* (Willd. ex Klotzsch) Graham), Euphorbiaceae, poinsettia ?#

Euryops chrysanthemoides *(DC.) B.Nord.*, Asteraceae, †Zimbabwe # but indigenous in South Africa

Fallopia
- convolvulus *(L.) Á.Löve* (= *Bilderdykia convolvulus* (L.) Dumort), Polygonaceae, climbing knotweed
- sachalinensis *(F.Schmidt) Ronse Decr.* (= *Polygonum sachalinense* F.Schmidt, *Reynoutria sachalinensis* (F.Schmidt) Nakai), Polygonaceae, giant knotweed, *2005 (PRE 1980) naturalized

Ficus
- carica *L.*, Moraceae, fig
- elastica *Roxb.* ex Hornem.(= *F. decora* hort.), Moraceae, rubber fig #
- macrophylla *Desf. ex Pers.*, Moraceae, Australian banyan #
- pumila *L.*, Moraceae, tickey creeper

Flaveria bidentis *(L.) Kuntze* (= *F. contrayerba* (Cav.) Pers.), Asteraceae, smelter's bush
Foeniculum vulgare *Mill.*, Apiaceae, fennel

Fraxinus
- americana *L.*, Oleaceae, American ash
- angustifolia *Vahl*, Oleaceae, Algerian ash
- sp., Oleaceae

Fuchsia sp., Onagraceae, fuchsia #
Fumaria muralis *Sond. ex Koch*, Fumariaceae, wall fumitory, *2001 #
Genista monspessulana *(L.) L.A.S.Johnson* (= *Cytisus candicans* (L.) DC., *C. monspessulanus* L.), Fabaceae, Montpellier broom

Glandularia
- aristigera *(S.Moore) Tronc.*(= *Verbena tenuisecta* Briq.), Verbenaceae, fine-leaved verbena
- ×hybrida *(hort. ex Groenl. & Rümpler) G.L.Nesom & Pruski* (= *Verbena ×hybrida* hort. ex Groenl. ex Rümpler), Verbenaceae, garden verbena ?#

Glebionis coronaria *(L.) Cass. ex Spach* (= *Chrysanthemum coronarium* L.), Asteraceae, chrysanthemum greens
Gleditsia triacanthos *L.*, Fabaceae, honey locust
Glyceria maxima *(Hartm.) Holmb.* (= *G. aquatica* (L.) Wahlb., *Poa aquatica* L.), Poaceae, reed meadow grass, *2002 #
Gmelina arborea *Roxb.*, Verbenaceae, white teak, †Malawi # abundant locally
Gnaphalium luteoalbum *L.* (= *Pseudognaphalium luteoalbum* (L.) Hilliard & B.L.Burtt), Asteraceae, Jersey cudweed
Gomphrena celosioides *Mart.* (= *G. decumbens* Jacq.), Amaranthaceae, prostrate globe amaranth

Grevillea
- banksii *R.Br.*, Proteaceae, Bank's grevillea, *2004 # very abundant locally
- robusta *A.Cunn. ex R.Br.*, Proteaceae, Australian silky oak
- rosmarinifolia *A.Cunn.*, Proteaceae #
- sericea *(Sm.) R.Br.*, Proteaceae, pink spider flower #

Guilleminea densa *(Humb. & Bonpl. ex Schult.) Moq.* (= *Brayulinea densa* (Willd.) Small), Amaranthaceae, carrot weed

APPENDIX 5.—Species checklist (cont.)

Hakea
drupacea *(C.F.Gaertn.) Roem. & Schult.* (= *H. suaveolens* R.Br.), Proteaceae, sweet hakea
gibbosa *(Sm.) Cav.*, Proteaceae, rock hakea
salicifolia *(Vent.) B.L.Burtt* (= *H. saligna* (Andrews) Knight), Proteaceae, willow hakea
sericea *Schrad. & J.C.Wendl.*, Proteaceae, silky hakea
victoriae *J.Drumm.*, Proteaceae #

Harrisia martinii *(Labour.) Britton & Rose* (= *Eriocereus martinii* (Labour.) Riccob.), Cactaceae, harrisia
Hedera helix *L.* subsp. canariensis *(Willd.) Cout.*, Araliaceae, Algerian or Canary ivy, *2003 #

Hedychium
coccineum *Buch.-Ham. ex Sm.*, Zingiberaceae, red ginger lily
coronarium *J.König*, Zingiberaceae, white ginger lily
flavescens *Carey ex Roscoe*, Zingiberaceae, yellow ginger lily
gardnerianum *Sheppard ex Ker Gawl.*, Zingiberaceae, kahili ginger lily
sp., Zingiberaceae

Helianthus annuus *L.*, Asteraceae, common sunflower
Heliotropium amplexicaule *Vahl*, Boraginaceae, blue heliotrope
Hibiscus trionum *L.*, Malvaceae, bladderweed
Homalanthus populifolius *Graham*, Euphorbiaceae, Queensland poplar
Hordeum murinum *L.*, Poaceae, wild barley
Hydrilla verticillata *(L.f.) Royle*, Hydrocharitaceae, hydrilla, *2006 (PRE 1963 but misidentified) naturalized and very abundant at Pongolapoort Dam, KwaZulu-Natal
Hydrocotyle ranunculoides *L.f.*, Apiaceae, †Zimbabwe # abundant locally
Hylocereus undatus *(Haw.) Britton & Rose*, Cactaceae, night-blooming cereus

Hypericum
patulum *Thunb.* (= *H. patulum* var. *forrestii* Chitt.), Clusiaceae
perforatum *L.*, Clusiaceae, St. John's wort

Hypochaeris radicata *L.*, Asteraceae, hairy wild lettuce
Hypoestes phyllostachya *Baker*, Acanthaceae, polka-dot-plant, *2002 #

Ipomoea
alba *L.*, Convolvulaceae, moonflower
carnea *Jacq.* subsp. fistulosa *(Mart. ex Choisy) D.F.Austin* (= *I. fistulosa* Mart. ex Choisy), Convolvulaceae, potato bush
indica *(Burm.) Merr.* (= *I. congesta* R.Br.), Convolvulaceae, perennial morning glory
nil *(L.) Roth*, Convolvulaceae, Japanese morning glory
purpurea *(L.) Roth*, Convolvulaceae, common morning glory
sp., Convolvulaceae

Iris pseudacorus *L.*, Iridaceae, yellow flag, *2004 #
Jacaranda mimosifolia *D.Don*, Bignoniaceae, jacaranda

Jasminum
humile *L.*, Oleaceae, yellow bush jasmine
mesnyi *Hance*, Oleaceae, primrose jasmine ?#
polyanthum *Franch.*, Oleaceae, creeping jasmine, *2001 #

Jatropha
curcas *L.*, Euphorbiaceae, physic nut, *2005 (1979 in Wells *et al.* (1986))
gossypiifolia *L.*, Euphorbiaceae, coral plant
sp., Euphorbiaceae

Juniperus
pinchotii *Sudw.*, Cupressaceae, red-berry juniper #
sp., Cupressaceae
virginiana *L.*, Cupressaceae, red cedar

Koelreuteria paniculata *Laxm.* (= *K. apiculata* Rehder & E.H.Wilson), Sapindaceae, golden-rain tree *2001 #
Lactuca serriola *L.* (= *L. scariola* L.), Asteraceae, wild lettuce
Lagerstroemia indica *L.*, Lythraceae, pride-of-India
Lantana camara *L.*, Verbenaceae, lantana

Lemna
gibba *L.*, Lemnaceae, duckweed
sp., Lemnaceae

Lepidium
didymum *L.* (= *Coronopus didymus* (L.) Sm.), Brassicaceae, swinecress
draba *L.* (= *Cardaria draba* (L.) Desv.), Brassicaceae, hoary cardaria

Leptospermum laevigatum *(Gaertn.) F.Muell.*, Myrtaceae, Australian myrtle
Leucaena leucocephala *(Lam.) de Wit* (= *L. glauca* Benth.), Fabaceae, leucaena

Ligustrum
japonicum *Thunb.*, Oleaceae, Japanese wax-leaved privet
lucidum *W.T.Aiton*, Oleaceae, Chinese wax-leaved privet
ovalifolium *Hassk.*, Oleaceae, Californian privet
sinense *Lour.*, Oleaceae, Chinese privet
sp., Oleaceae
vulgare *L.*, Oleaceae, common privet

Lilium formosanum *Wallace* (= *L. longiflorum* Thunb. var. *formosanum* Baker, *L. phillipinense* Baker), Liliaceae, Saint Joseph's lily
Limonium sinuatum *(L.) Mill.* (= *Statice sinuata* L.), Plumbaginaceae, statice

Linaria
genistifolia *(L.) Mill.* (= *L. dalmatica* (L.) Mill.), Scrophulariaceae, yellow linaria
maroccana *Hook.f.*, Scrophulariaceae, baby snapdragon

Litsea glutinosa *(Lour.) C.B.Rob.* (= *L. sebifera* Pers.), Lauraceae, Indian laurel
Lonicera japonica *Thunb.* 'Halliana', Caprifoliaceae, Japanese honeysuckle
Lygodium japonicum *(Thunb.) Sw.*, Schizaeaceae, Japanese climbing fern #
Lythrum salicaria *L.*, Lythraceae, purple loosestrife
Macfadyena unguis-cati *(L.) A.H.Gentry*, Bignoniaceae, cat's claw creeper
Maireana brevifolia *(R.Br.) Paul G.Wilson* (= *Kochia brevifolia* R.Br.), Chenopodiaceae, small-leaf bluebush #
Malus pumila *Mill.* var. paradisiaca *C.K.Schneid.*, Rosaceae, paradise apple ?#

Malva
dendromorpha *M.F.Ray* (= *Lavatera arborea* L.), Malvaceae, tree mallow
linnaei *M.F.Ray* (= *Lavatera cretica* L.), Malvaceae, Cretan hollyhock
parviflora *L.*, Malvaceae, small mallow

Malvastrum coromandelianum *(L.) Garcke*, Malvaceae, prickly malvastrum
Mangifera indica *L.*, Anacardiaceae, mango

Manihot
esculenta *Crantz* (= *M. utilissima* Pohl), Euphorbiaceae, bitter cassava
grahamii *Hook.* (= *M. dulcis* (J.F.Gmel.) Pax var. *multifida* (Graham) Pax), Euphorbiaceae, hardy cassava #

Medicago sativa *L.* (= *M. falcata* L.), Fabaceae, alfalfa

Melaleuca
hypericifolia *Sm.*, Myrtaceae, red-flowering tea tree
wilsonii *F.Muell.*, Myrtaceae, violet honey-myrtle #

Melia azedarach *L.*, Meliaceae, seringa or 'syringa'
Melilotus alba *Medik.*, Fabaceae, white sweet clover
Metasequoia glyptostroboides *Hu & W.C.Cheng*, Cupressaceae, dawn redwood #
Metrosideros excelsa *Sol. ex Gaertn.* (= *M. tomentosa* A. Rich.), Myrtaceae, New Zealand bottlebrush
Michelia champaca *L.*, Magnoliaceae, champac magnolia, †Zimbabwe #

Mimosa
pigra *L.*, Fabaceae, giant sensitive plant
pudica *L.* var. hispida *Brenan*, Fabaceae, sensitive plant

Mirabilis jalapa *L.*, Nyctaginaceae, four-o'clock
Momordica charantia *L.*, Cucurbitaceae, bitter cucumber
Mondia whitei *(Hook.f.) Skeels* (= Chlorocodon whitei Hook.f.), Apocynaceae, †Zimbabwe & Malawi # but indigenous in South Africa
Monstera deliciosa *Liebm.*, Araceae, Swiss-cheese plant #
Montanoa hibiscifolia *Benth.*, Asteraceae, tree daisy
Moringa oleifera *Lam.* (= *M. pterygosperma* Gaertn.), Moringaceae, horse-radish tree #
Morus alba *L.*, Moraceae, white or common mulberry
Musa sp., Musaceae, banana tree #
Murraya paniculata *(L.) Jack.* (= *M. exotica* L.), Rutaceae, orange jessamine, *2005 #
Myoporum tenuifolium *G.Forst.* subsp. montanum *(R.Br.) Chinnock* (= *M. montanum* R.Br.)(*M. acuminatum* R.Br. misapplied in South Africa), Myoporaceae, manatoka

Myriophyllum
aquaticum *(Vell.) Verdc.* (= *M. brasiliense* Cambess.), Haloragaceae, parrot's feather
spicatum *L.*, Haloragaceae, spiked water-milfoil

Nassella
tenuissima *(Trin.) Barkworth* (= *Stipa tenuissima* Trin.), Poaceae, white tussock
trichotoma *(Nees) Hack. ex Arechav.* (= *Stipa trichotoma* Nees), Poaceae, nassella tussock

Nasturtium officinale *R.Br.* (= *Rorippa nasturtium-aquaticum* (L.) Hayek), Brassicaceae, watercress
Nephrolepis exaltata *(L.) Schott*, Nephrolepidaceae, sword fern

APPENDIX 5.—Species checklist (cont.)

Nerium oleander *L.*, Apocynaceae, oleander
Nicandra physalodes *(L.) Gaertn.*, Solanaceae, apple-of-Peru

Nicotiana
glauca *Graham*, Solanaceae, wild tobacco
tabacum *L.*, Solanaceae, tobacco ?#

Nymphaea
mexicana *Zucc.*, Nymphaeaceae, yellow waterlily
×marliacea *W.Watson*, Nymphaeaceae, Marliac hybrid waterlily

Oenothera
biennis *L.*, Onagraceae, evening primrose
glazioviana *Micheli* (= *O. erythrosepala* Borbás), Onagraceae, evening primrose
indecora *Cambess.*, Onagraceae, evening primrose
jamesii *Torr. & A.Gray*, Onagraceae, giant evening primrose
laciniata *Hill*, Onagraceae, cutleaf evening primrose
rosea *L'Hér. ex Aiton*, Onagraceae, rose evening primrose
sp., Onagraceae
tetraptera *Cav.*, Onagraceae, white evening primrose

Olyra latifolia *L.*, Poaceae

Opuntia
aurantiaca *Lindl.*, Cactaceae, jointed cactus
engelmannii *Salm-Dyck ex Engelm.* (= *O. lindheimeri* Engelm.), Cactaceae, small round-leaved prickly pear
exaltata *A.Berger* (= *Austrocylindropuntia exaltata* (A.Berger) Backeb.), Cactaceae, long-spine cactus
ficus-indica *(L.) Mill.* (= *O. megacantha* Salm-Dyck), Cactaceae, sweet prickly pear
fulgida *Engelm.* (= *Cylindropuntia fulgida* (Engelm.) F.M.Knuth)(*O. rosea* DC. and *Cylindropuntia rosea* (DC.) Backeb. misapplied in South Africa), Cactaceae, chainfruit cholla or 'rosea cactus'
humifusa *(Raf.) Raf.* (= *O. compressa* auct.), Cactaceae, large-flowered prickly pear
imbricata *(Haw.) DC.* (= *Cylindropuntia imbricata* (Haw.) F.M.Knuth), Cactaceae, imbricate prickly pear
microdasys *(Lehm.) Pfeiff.*, Cactaceae, yellow bunny-ears
monacantha *Haw.* (= *O. vulgaris* auct.), Cactaceae, cochineal prickly pear
robusta *H.L.Wendl. ex Pfeiff.*, Cactaceae, blue-leaf cactus
sp., Cactaceae
spinulifera *Salm-Dyck*, Cactaceae, large round-leaved prickly pear ?#
stricta *(Haw.) Haw.* (possibly both var. dillenii and var. stricta), Cactaceae, Australian pest pear
stricta ×humifusa?, Cactaceae
tomentosa *Salm-Dyck*, Cactaceae, velvet opuntia, *2003 #

Orobanche minor *Sm.*, Orobanchaceae, clover broomrape
Oxalis corniculata *L.*, Oxalidaceae, creeping oxalis
Pandanus sp., Pandanaceae, screw-pine #
Paraserianthes lophantha *(Willd.) I.C.Nielsen* (= *Albizia lophantha* (Willd.) Benth.), Fabaceae, stinkbean
Parkinsonia aculeata *L.*, Fabaceae, Jerusalem thorn
Parthenium hysterophorus *L.*, Asteraceae, parthenium
Parthenocissus quinquefolia *(L.) Planch.*, Vitaceae, Virginia creeper #

Paspalum
dilatatum *Poir.*, Poaceae, common paspalum
notatum *Flüggé*, Poaceae, *2006 (PRE 1944)
quadrifarium *Lam.*, Poaceae
urvillei *Steud.*, Poaceae, tall paspalum

Passiflora
caerulea *L.*, Passifloraceae, blue passion flower
edulis *Sims*, Passifloraceae, purple granadilla
sp., Passifloraceae
suberosa *L.*, Passifloraceae, devil's pumpkin
subpeltata *Ortega*, Passifloraceae, granadina
tripartita *(Juss.) Poir.* var. mollissima *(Kunth) Holm-Niels. & P.Jorg.* (= *P. mollissima* (Kunth) L.H.Bailey), Passifloraceae, banana poka

Pennisetum
clandestinum *Hochst. ex Chiov.*, Poaceae, Kikuyu grass
purpureum *Schumach.*, Poaceae, Napier grass
setaceum *(Forssk.) Chiov.*, Poaceae, fountain grass
sp., Poaceae
villosum *R.Br. ex Fresen.*, Poaceae, feathertop

Pereskia aculeata *Mill.*, Cactaceae, pereskia
Persea americana *Mill.* (= *P. gratissima* C.F.Gaertn.), Lauraceae, avocado pear #
Persicaria lapathifolia *(L.) Gray* (= *Polygonum lapathifolium* L.), Polygonaceae, spotted knotweed

Phoenix
canariensis *Hort. ex Chabaud*, Arecaceae, Canary date palm
dactylifera *L.*, Arecaceae, real date palm

Phormium tenax *J.R.Forst. & G.Forst.*, Phormiaceae, New Zealand flax #

Physalis
peruviana *L.*, Solanaceae, Cape gooseberry
viscosa *L.*, Solanaceae, sticky gooseberry

Phytolacca
dioica *L.*, Phytolaccaceae, belhambra
icosandra *L.* (= *P. octandra* L.), Phytolaccaceae, forest inkberry

Pinus
canariensis *C.Sm.*, Pinaceae, Canary pine
elliottii *Engelm.*, Pinaceae, slash pine
halepensis *Mill.*, Pinaceae, Aleppo pine
patula *Schiede ex Schltdl. & Cham.*, Pinaceae, patula pine
pinaster *Aiton*, Pinaceae, cluster pine
pinea *L.*, Pinaceae, umbrella pine
radiata *D.Don*, Pinaceae, radiata pine
roxburghii *Sarg.* (= *P. longifolia* Roxb. ex Lamb.), Pinaceae, chir pine
sp., Pinaceae
taeda *L.*, Pinaceae, loblolly pine

Pistia stratiotes *L.*, Araceae, water lettuce
Pittosporum undulatum *Vent.*, Pittosporaceae, Australian cheesewood
Pityrogramma calomelanos *(L.) Link*, Adiantaceae, golden fern

Plantago
lanceolata *L.*, Plantaginaceae, narrow-leaved ribwort
major *L.*, Plantaginaceae, broad-leaved ribwort
virginica *L.*, Plantaginaceae, dwarf plantain

Platanus
sp., Platanaceae #
×acerifolia *(Aiton) Willd.* (= *P. hispanica* auct.), Platanaceae, London planetree, *2004 #

Plectranthus comosus *Sims* (= *Coleus grandis* Cramer)(*P. barbatus* Andrews misapplied in South Africa), Lamiaceae, Abyssinian coleus
Polygonum aviculare *L.*, Polygonaceae, prostrate knotweed
Polypogon monspeliensis *(L.) Desf.*, Poaceae, beardgrass
Pomaderris kumeraho *A.Cunn.*, Rhamnaceae, kumarahou #
Pontederia cordata *L.*, Pontederiaceae, pickerel weed

Populus
alba *L.*, Salicaceae, white poplar
deltoides *W.Bartram ex Marshall*, Salicaceae, match poplar
nigra *L.* var. italica *Münchh.*, Salicaceae, Lombardy poplar
×canescens *(Aiton) Sm.*, Salicaceae, grey poplar

Portulaca oleracea *L.*, Portulacaceae, purslane

Prosopis
glandulosa *Torr.* var. torreyana *(Benson) Johnst.*, Fabaceae, honey mesquite
velutina *Wooton*, Fabaceae, velvet mesquite

Prunus
armeniaca *L.*, Rosaceae, apricot
cerasoides *D.Don*, Rosaceae, Himalayan flowering cherry, †Zimbabwe # abundant locally
persica *(L.) Batsch*, Rosaceae, peach
serotina *Ehrh.*, Rosaceae, black cherry

Psidium
cattleianum *Sabine* (= *P. littorale* Raddi var. *longipes* (O.Berg) Fosberg), Myrtaceae, strawberry guava
guajava *L.*, Myrtaceae, guava
guineense *Sw.*, Myrtaceae, Brazilian guava
sp., Myrtaceae
×durbanensis *Baijnath ined.*, Myrtaceae, Durban guava

Pterocarya stenoptera *C.DC.*, Juglandaceae, Chinese wing-nut #
Pueraria montana *(Lour.) Merr.* var. lobata *(Willd.) Maesen & S.M.Almeida* (= *P. lobata* (Willd.) Ohwi), Fabaceae, kudzu vine
Punica granatum *L.*, Punicaceae, pomegranate

Pyracantha
angustifolia *(Franch.) C.K.Schneid.*, Rosaceae, yellow firethorn
coccinea *M.Roem.*, Rosaceae, red firethorn
crenulata *(D.Don) M.Roem.*, Rosaceae, Himalayan firethorn
sp., Rosaceae

Pyrus sp., Rosaceae, pear tree ?#

Quercus
canariensis *Willd.* (= *Q. mirbeckii* Durieu), Fagaceae, Algerian oak ?#
cerris *L.*, Fagaceae, Turkey oak ?#
palustris *Münchh.*, Fagaceae, pin oak
robur *L.*, Fagaceae, English oak
sp., Fagaceae
suber *L.*, Fagaceae, cork oak ?#

Quisqualis indica *L.*, Combretaceae, Rangoon creeper *2006 #

Richardia
brasiliensis *Gomes*, Rubiaceae, tropical richardia
humistrata *Steud.*, Rubiaceae, Peelton richardia

APPENDIX 5.—Species checklist (cont.)

Ricinus communis *L.*, Euphorbiaceae, castor-oil plant
Rivina humilis *L.*, Phytolaccaceae, bloodberry
Robinia pseudoacacia *L.*, Fabaceae, black locust

Rosa
multiflora *Thunb.*, Rosaceae, multiflora rose
rubiginosa *L.* (= *R. eglanteria* L.), Rosaceae, eglantine
sp., Rosaceae #
?×odorata *(Andrews) Sweet*, Rosaceae, tea rose #

Rubus
cuneifolius *Pursh*, Rosaceae, American bramble
flagellaris *Willd.*, Rosaceae
fruticosus *L.* agg., Rosaceae, European blackberry
?pascuus *L.H.Bailey*, Rosaceae
phoenicolasius *Maxim.*, Rosaceae
rosifolius *Sm.*, Rosaceae
sp., Rosaceae
×proteus *C.H.Stirt.*, Rosaceae, Bramble, Graskop/Sabie hybrid

Rumex
acetosella *L.* subsp. pyrenaicus *(Pourr. ex Lapeyr.) Akeroyd* (= *R. angiocarpus* auct.), Polygonaceae, sheep sorrel
crispus *L.*, Polygonaceae, curly dock
usambarensis *(Dammer) Dammer* (= *R. nervosus* Vahl var. *usambarensis* Dammer), Polygonaceae, rumex

Saccharum officinarum *L.*, Poaceae, sugar cane

Salix
babylonica *L.*, Salicaceae, weeping willow
caprea *L.*, Salicaceae, pussy willow
fragilis *L.*, Salicaceae, crack willow

Salsola
kali *L.*, Chenopodiaceae, common saltwort
tragus *L.* (= *S. australis* R.Br.), Chenopodiaceae, Russian tumbleweed

Salvia tiliifolia *Vahl*, Lamiaceae, Lindenleaf sage, *2005 (PRE 1943)
Salvinia molesta *D.S.Mitch.* (*S. auriculata* Aubl. misapplied in South Africa), Salviniaceae, Kariba weed

Sambucus
canadensis *L.* (= *S. nigra* L. subsp. *canadensis* (L.) Bolli), Caprifoliaceae, Canadian elder
nigra *L.*, Caprifoliaceae, European elder, *2004
sp., Caprifoliaceae

Schefflera
actinophylla *(Endl.) Harms* (= *Brassaia actinophylla* Endl.), Araliaceae, Australian cabbage tree #
arboricola *(Hayata) Merr.*, Araliaceae, dwarf umbrella tree, *2005 #
elegantissima *(hort. Veitch. ex Mast.) Lowry & Frodin* (= *Dizygotheca elegantissima* (hort. Veitch. ex Mast.) R.Vig. Guillaumin), Araliaceae, *2005 #

Schinus
molle *L.*, Anacardiaceae, pepper tree
terebinthifolius *Raddi*, Anacardiaceae, Brazilian pepper tree

Schizolobium parahyba *(Vell.) S. F.Blake* var. parahyba (= *S. excelsum* Vogel), Fabaceae, parasol tree #
Schkuhria pinnata *(Lam.) Kuntze ex Thell.*, Asteraceae, dwarf marigold

Senna
bicapsularis *(L.) Roxb.* (= *Cassia bicapsularis* L.), Fabaceae, rambling cassia
corymbosa *(Lam.) H.S.Irwin & Barneby* (= *Cassia corymbosa* Lam.), Fabaceae, autumn cassia
didymobotrya *(Fresen.) H.S.Irwin & Barneby* (= *Cassia didymobotrya* Fresen.), Fabaceae, peanut butter cassia
hirsuta *(L.) H.S.Irwin & Barneby* (= *Cassia hirsuta* L.), Fabaceae
multiglandulosa *(Jacq.) H.S.Irwin & Barneby* (= *Cassia multiglandulosa* Jacq., *C. tomentosa* L.f.), Fabaceae
obtusifolia *(L.) H.S.Irwin & Barneby* (= *Cassia obtusifolia* L.), Fabaceae
occidentalis *(L.) Link* (= *Cassia occidentalis* L.), Fabaceae, wild coffee
pendula *(Willd.) H.S.Irwin & Barneby* var. glabrata *(Vogel) H.S.Irwin & Barneby* (= *Cassia colutcoides* Collad.), Fabaceae
septemtrionalis *(Viv.) H.S.Irwin & Barneby* (= *Cassia floribunda* sensu Brenan non Cav.), Fabaceae, arsenic bush
sp., Fabaceae

Sesbania
bispinosa *(Jacq.) W.Wight* var. bispinosa (= *S. aculeata* Pers.), Fabaceae, spiny sesbania
punicea *(Cav.) Benth.*, Fabaccae, red sesbania

Sigesbeckia orientalis *L.*, Asteraceae, St. Paul's wort
Silybum marianum *(L.) Gaertn.*, Asteraceae, milk thistle
Sisymbrium orientale *L.*, Brassicaceae, Indian hedge mustard
Sisyrinchium sp., Iridaccae

Solanum
bctaceum *Cav.* (= *Cyphomandra betacea* (Cav.) Sendtn.), Solanaceae, tree tomato
capsicoides *All.*, Solanaceae, devil's apple
chrysotrichum *Schltdl.* (= *S. hispidum* auctt. non Pers.), Solanaceae, giant devil's fig
elaeagnifolium *Cav.*, Solanaceae, silver-leaf bitter apple
mauritianum *Scop.* (= *S. auriculatum* Aiton), Solanaceae, bugweed
pseudocapsicum *L.*, Solanaceae, Jerusalem cherry
seaforthianum *Andrews*, Solanaceae, potato creeper
sisymbriifolium *Lam.*, Solanaceae, dense-thorned bitter apple
sp., Solanaceae
torvum *Sw.* (= *S. mannii* C.H.Wright), Solanaceae
viarum *Dunal*, Solanaceae, tropical soda apple, *2006 (PRE 1962)

Sonchus oleraceus *L.*, Asteraceae, sowthistle
Sophora cf. davidii *(Franch.) Skeels*, Fabaceae #
Sorghum halepense *(L.) Pers.* (= *S. almum* Parodi), Poaceae, Johnson grass
Spartium junceum *L.*, Fabaceae, Spanish broom
Spathodea campanulata *P.Beauv.*, Bignoniaceae, African flame tree
Sphagneticola trilobata *(L.) Pruski* (= *Thelechitonia trilobata* (L.) H.Rob. & Cuatrec, *Wedelia trilobata* (L.) Hitchc.), Asteraceae, Singapore daisy
Spiraea cantoniensis *Lour.*, Rosaceae, Cape may #
Stellaria media *(L.) Vill.*, Caryophyllaceae, chickweed
Stenocarpus sinuatus *Endl.*, Proteaceae, firewheel tree ?#
Styphnolobium japonicum *(L.) Schott* (= *Sophora japonica* L.), Fabaceae, Japanese pagoda tree ?#
Symphyotrichum subulatum *(Michx.) G.L.Nesom* var. squamatum *(Spreng.) S.D.Sundb.* (= *Aster squamatus* (Spreng.) Hieron.), Asteraceae, swamp aster
Syncarpia glomulifera *(Sm.) Nied.* (= *S. laurifolia* Ten.), Myrtaceae, turpentine tree

Syzygium
cumini *(L.) Skeels*, Myrtaceae, jambolan
jambos *(L.) Alston*, Myrtaceae, rose apple
paniculatum *Gaertn.* (= *Eugenia myrtifolia* Sims), Myrtaceae, Australian water pear

Tabebuia chrysotricha *(Mart. ex DC.) Standl.* (= *Tecoma chrysotricha* Mart. ex DC.), Bignoniaceae, yellow trumpet tree ?#
Tagetes minuta *L.*, Asteraceae, khaki weed

Tamarix
chinensis *Lour.*, Tamaricaceae, Chinese tamarisk
ramosissima *Ledeb.*, Tamaricaceae, pink tamarisk
sp., Tamaricaceae

Taraxacum officinale *F.H.Wigg.* agg., Asteraceae, common dandelion

Tecoma
stans *(L.) Juss. ex Kunth*, Bignoniaceae, yellow bells
tenuiflora *(A.DC.) Fabris*, Bignoniaceae, *2004

Tephrocactus
articulatus *(Pfeiff.) Backeb.*, Cactaceae, paper-spine cholla
?aoracanthus *(Lem.) Lem.* (= ?*Opuntia aoracantha* Lemaire), Cactaceae
sp., Cactaceae

Thevetia peruviana *(Pers.) K.Schum.* (= *T. neriifolia* Juss. ex Steud.), Apocynaceae, yellow oleander

Tipuana tipu *(Benth.) Kuntze* (= *T. speciosa* Benth.), Fabaceae, tipu tree

Tithonia
diversifolia *(Hemsl.) A.Gray*, Asteraceae, Mexican sunflower
rotundifolia *(Mill.) S.F.Blake*, Asteraceae, red sunflower

Toona ciliata *M.Roem.* (= *Cedrela toona* Roxb. ex Willd.), Meliaceae, toon tree
Torilis arvensis *(Huds.) Link.*, Apiaceae, spreading hedge-parsley
Toxicodendron succedaneum *(L.) Kuntze* (= *Rhus succedanea* L.), Anacardiaceae, wax tree

Tradescantia
zebrina *hort. ex Bosse* (= *Zebrina pendula* Schnizl.), Commelinaceae, wandering jew, *2005 #
fluminensis *Vell.*, Commelinaceae, wandering Jew, *2001 (Wells *et al.* 1986)

Tragopogon dubius *Scop.* (= *T. major* Jacq.), Asteraceae, yellow salsify
Tridax procumbens *L.*, Asteraceae, tridax daisy
Triplaris americana *L.*, Polygonaceae, triplaris ?#
Triticum aestivum *L.*, Poaceae, volunteer wheat
Tropaeolum majus *L.*, Tropaeolaceae, nasturtium
Ulex europaeus *L.*, Fabaceae, European gorse

Ulmus
parvifolia *Jacq.* (= *U. chinensis* Pers.), Ulmaceae, Chinese elm
procera *Salisb.*, Ulmaceae, English elm #
sp., Ulmaceae #

Verbena
bonariensis *L.*, Verbenaceae, wild verbena

APPENDIX 5.—Species checklist (cont.)

Verbena (cont.)
brasiliensis *Vell.*, Verbenaceae, slender wild verbena
officinalis *L.*, Verbenaceae, European verbena
rigida *Spreng.* var. rigida (= *V. venosa* Gillies & Hook.), Verbenaceae, veined vervain

Verbesina encelioides *(Cav.) Benth. & Hook.f. ex A.Gray*, Asteraceae, golden crownbeard

Vinca major *L.*, Apocynaceae, greater periwinkle

Viola
hederacea *Labill.* (= *Erpetion reniforme* Sweet), Violaceae, Australian violet, *2001 #
priceana *Pollard* (= *V. sororia* Willd.), Violaceae, confederate violet, *2005 #

Vitex
agnus-castus *L.*, Verbenaceae, lilac chastetree, *2004 (PRE 1975)
trifolia *L.*, Verbenaceae, Indian three-leaf vitex, *2004 #
sp., Vitaceae, grape #

Washingtonia sp., Arecaceae, petticoat palm ?#

Wigandia urens *(Ruiz & Pav.) Kunth* var. caracasana *(Kunth) D.N.Gibson* (= *W. caracasana* Kunth), Hydrophyllaceae, wigandia #

Wisteria floribunda *(Willd.) DC.*, Fabaceae, Japanese wisteria #

Xanthium
sp., Asteraceae
spinosum *L.*, Asteraceae, spiny cocklebur
strumarium *L.*, Asteraceae, large cocklebur

Yucca aloifolia *L.*, Agavaceae, Spanish bayonet

Zinnia peruviana *(L.) L.* (= *Z. multiflora* L.), Asteraceae, redstar zinnia

APPENDIX 6.—Characteristics of prominent invaders in study area

Plant name	Family	Origin	GF	W	LC	P	SR	VR	Disp. agent	Cult. use	VC
Acacia											
cyclops	Fabaceae	ST (Aus.)	t/s	woo	per	ev	seed		bir, mam	#c/b, bar	sa, fy, sk
dealbata	Fabaceae	ST (Aus.)	t	woo	per	ev	seed	cop	wat, ?ant, ?bir	silc, #bar, orn	sa, fo, gr
decurrens	Fabaceae	ST (Aus.)	t	woo	per	ev	seed	cop	wat, ?ant, ?bir	silc, #bar, orn	gr
longifolia	Fabaceae	ST (Aus.)	t/s	woo	per	ev	seed		wat, bir, ant	#c/b, bar, orn	fy, fo
mearnsii	Fabaceae	ST (Aus.)	t	woo	per	ev	seed	cop	wat, ?ant, ?bir	#silc, bar, orn	sa, fy, fo, gr, sk
melanoxylon	Fabaceae	ST (Aus.)	t	woo	per	ev	seed	suc	bir, wat	#silc, bar, orn	fy, fo
pycnantha	Fabaceae	ST (Aus.)	t	woo	per	ev	seed		wat, mam, ?bir	#silc, c/b, bar, orn	fy
saligna	Fabaceae	ST (Aus.)	t/s	woo	per	ev	seed	cop	wat, mam, ant	silc, agrc, #c/b, bar, orn	sa, fy, fo, sk
Achyranthes aspera	Amaranthaceae	T (?Afr.)	h	her	per	ev/d	seed		mam	none	fo
Agave											
americana var. *americana*	Agavaceae	T (Am.)	s	suc	per	ev	seed	suc	win, hum	orn, #bar, agrc	sa, nk
sisalana	Agavaceae	T (Am.)	s	suc	per	ev		suc, bul	wat, hum	bar, #agrc, orn	sa
Ageratum											
conyzoides	Asteraceae	T (Am.)	h	her	ann	germ	seed		win	#orn	sa, fo
houstonianum	Asteraceae	T (Am.)	h	her	ann	germ	seed		win	#orn	sa, fo
Argemone											
mexicana	Papaveraceae	T (Am.)	h	her	ann	germ	seed		wat, ?hum (soil),?ant	none	sa
ochroleuca subsp. *ochroleuca*	Papaveraceae	T (Am.)	h	her	ann	germ	seed		wat, ?hum (soil),?ant	none	sa
Arundo donax	Poaceae	NT (Med. & Asia)	g/r	sem	per	ev		rhz, div	wat, hum	#agrc, orn, bar	sa, fy, gr, nk, sk
Atriplex											
inflata	Chenopodiaceae	ST (Aus.)	h	sem	per	ev/d	seed		win	#?agrc	nk, sk
nummularia subsp. *nummularia*	Chenopodiaceae	ST (Aus.)	s	woo/sem	per	ev/d	seed		win	#agrc, bar	nk, sk
Azolla filiculoides	Azollaceae	T (Am.)	h	her	var	var	spore	div	wat, bir	#orn	gr, nk
Caesalpinia decapetala	Fabaceae	Tl (Asia)	s/c	woo	per	ev	seed		wat, ?hum, mam (cattle)	#bar, orn	sa, fo, gr
Cardiospermum											
grandiflorum	Sapindaceae	T (Am.)	c	sem	per	ev/d	seed		wat, win	#orn	sa, fo
halicacabum	Sapindaceae	T (?Am.)	c	sem	per	ev/d	seed		wat, win	#orn	sa

Origin: ST, southern temperate, south of or straddling Tropic of Capricorn; NT, northern temperate, north of or straddling Tropic of Cancer; T, tropical, between or straddling Tropics of Capricorn and Cancer. GF, growth form: **tree**; **tree/shrub**; **shrub**; **herb**; **herb/shrub**; **grass**; **grass/reed**; **climber**; **shrub/climber**.
W, woodiness: **woo**dy; **semi**-woody; **herb**aceous; **succulent**.
LC, life cycle: **per**ennial, **ann**ual, **var**iable, **bi**ennial.
P, perennation: **ev**ergreen; **d**eciduous; **ev**ergreen/**d**eciduous; **var**iable; **germ**inative.
SR, sexual reproduction: seed, spore.
VR, vegetative reproduction: **cop**pice; **suc**ker; **div**ision; rhz, rhizome; **bul**bil; **sto**lon; **tub**er; **run**ner.
Dispersal agent: **wind**; **water**; **bird**; **mam**mal; **hum**an; ant.
Cultivated use: # primary (= major) use; **orn**amental; **barr**ier; **c**over/**b**inder; **agr**icultural **c**rop; **sil**vicultural **c**rop; none.
VC, vegetation category: **sa**vanna biome; **fy**nbos biome; **for**est habitats; **gr**assland biome; **nama-k**aroo biome; succulent **k**aroo biome.
Afr., Africa; Am., America; Aus., Australia; Eur., Europe; Med., Mediterranean.

APPENDIX 6.—Characteristics of prominent invaders in study area (cont.)

Plant name	Family	Origin	GF	W	LC	P	SR	VR	Disp. agent	Cult. use	VC
Casuarina											
cunninghamiana	Casuarinaceae	T (Aus.)	t	woo	per	ev	seed		wat, win	orn, c/b, #bar	fo
equisetifolia	Casuarinaceae	T (Pantrop.)	t	woo	per	ev	seed		wat, win	orn, #c/b, bar	fo
Cereus jamacaru	Cactaceae	T (Am.)	t/s	suc	per	ev	seed	div	bir	#orn, bar	sa
Cestrum laevigatum	Solanaceae	T (Am.)	t/s	woo	per	ev	seed		bir	#orn, bar	sa, fo
Chromolaena odorata	Asteraceae	T (Am.)	s	woo	per	ev	seed		win	#orn	sa, fo
Cinnamomum camphora	Lauraceae	NT (Asia)	t	woo	per	ev	seed		bir	#orn, silc, agrc	fo
Cirsium vulgare	Asteraceae	NT (Eur., N Afr. & Asia)	h	her	bie	germ	seed		win	none	gr
Datura											
ferox	Solanaceae	T (Am.)	h	her	ann	germ	seed		wat, ?hum (soil), ?ant	none	sa, gr
innoxia	Solanaceae	T(Am.)	h	her	var	var	seed		wat, ?hum (soil), ?ant	none	sa, gr
stramonium	Solanaceae	T (Am.)	h	her	ann	germ	seed		wat, ?hum (soil), ?ant	#agrc	sa, gr
Eichhornia crassipes	Pontederiaceae	T (Am.)	h	her	per	ev	seed	div	wat, hum	#orn	sa, fy, gr
Eucalyptus											
camaldulensis	Myrtaceae	T (Aus.)	t	woo	per	ev	seed	cop	wat, win	#silc, bar, orn, agrc	fy, fo, sk
diversicolor	Myrtaceae	ST (Aus.)	t	woo	per	ev	seed	cop	win	#silc, bar, agrc, orn	fy, fo
grandis	Myrtaceae	T (Aus.)	t	woo	per	ev	seed	cop	win	#silc, bar, orn, agrc	sa, fo, gr
Hakea sericea	Proteaceae	ST (Aus.)	t/s	woo	per	ev	seed		win	orn, c/b, #bar	fy
Hedychium											
coccineum	Zingiberaceae	NT (Asia)	h	her	per	ev	seed	rhz	bir, wat	#orn	fo
coronarium	Zingiberaceae	NT (Asia)	h	her	per	ev	seed	rhz	bir, wat	#orn	fo
gardnerianum	Zingiberaceae	NT (Asia)	h	her	per	ev	seed	rhz	bir, wat	#orn	fo
Ipomoea											
indica	Convolvulaceae	T (Am.)	c	her	per	ev	seed		?win, wat	#orn	sa, fo
purpurea	Convolvulaceae	T (Am.)	c	her	ann	germ	seed		?win, wat	#orn	sa, fo
Jacaranda mimosifolia	Bignoniaceae	T (Am.)	t	woo	per	d	seed	cop	win	#orn	sa, fo
Lantana camara	Verbenaceae	T (Am.)	s	woo	per	ev/d	seed	cop, ?run	bir	#orn, bar	sa, fo, gr
Leptospermum laevigatum	Myrtaceae	ST (Aus.)	t/s	woo	per	ev	seed		win,wat	orn, #bar, c/b	fy
Ligustrum											
japonicum	Oleaceae	NT (Asia)	t/s	woo	per	ev	seed	cop	bir	orn, #bar	fo
lucidum	Oleaceae	NT (Asia)	t/s	woo	per	ev	seed	cop	bir	orn, #bar	fo
Litsea glutinosa	Lauraceae	T (Asia)	t/s	woo	per	ev	seed	?cop	bir	#orn	fo
Macfadyena unguis-cati	Bignoniaceae	T (Am.)	c	sem	per	ev/d	seed	cop, tub	win	#orn	sa, fo
Melia azedarach	Meliaceae	T(Aus.)	t	woo	per	d	seed	cop	bir, wat	#orn	sa, fo, gr
Morus alba	Moraceae	NT (Asia)	t	woo	per	d	seed	cop	bir	orn, #agrc	sa, fo, gr
Nephrolepis exaltata	Davalliaceae	T (Am.)	h	her	per	ev	sp	sto, tub	win, hum	#orn	fo
Nicotiana glauca	Solanaceae	T (Am.)	t/s	woo	per	ev	seed	cop	win, wat, ?hum (soil)	#orn	sa, fy, nk, sk
Opuntia											
ficus-indica	Cactaceae	T (Am.)	t/s	suc	per	ev	seed	div	mam, bir	#agrc, bar	sa, fy, fo, gr, nk, sk
robusta	Cactaceae	T (Am.)	?t/s	suc	per	ev	seed	div	mam, bir	#agrc, bar	nk
stricta	Cactaceae	T (Am.)	s	suc	per	ev	seed	div	mam, bir	#orn	sa
Paraserianthes lophantha	Fabaceae	ST (Aus.)	t/s	woo	per	ev	seed	?cop	wat	#orn; agrc	fy
Passiflora edulis	Passifloraceae	T (Am.)	c	her	per	ev	seed		mam, bir	orn, #agrc	fo
Pennisetum clandestinum	Poaceae	T (Afr.)	g	her	per	ev/d	seed	rhz, sto	?win, hum	#c/b, agrc	fo
Pereskia aculeata	Cactaceae	T (Am.)	s/c	suc	per	ev	seed	div	bir, ?mam, hum	#bar, orn	fo

Origin: ST, southern temperate, south of or straddling Tropic of Capricorn; NT, northern temperate, north of or straddling Tropic of Cancer; T, tropical, between or straddling Tropics of Capricorn and Cancer. GF, growth form: **tree**; **tree/shrub**; **shrub**; **herb**; **herb/shrub**; **grass**; **grass/reed**; climber; shrub/climber.
W, woodiness: **woo**dy; **semi**-woody; **her**baceous; **succulent**.
LC, life cycle: **per**ennial, **ann**ual, **var**iable, **bi**ennial.
P, perennation: **ev**ergreen; **d**eciduous; evergreen/**d**eciduous; **var**iable; **germ**inative.
SR, sexual reproduction: seed, spore.
VR, vegetative reproduction: **cop**pice; **suc**ker; **div**ision; rhz, rhizome; **bul**bil; **sto**lon; **tub**er; **run**ner.
Dispersal agent: **wind**; **water**; **bird**; **mam**mal; **hum**an; ant.
Cultivated use: # primary (= major) use; **orn**amental; **barrier**; **cover/binder**; **agricultural** crop; **silvicultural** crop; none.
VC, vegetation category: **sa**vanna biome; **fy**nbos biome; **fo**rest habitats; **gr**assland biome; **nama-k**aroo biome; succulent **k**aroo biome.
Afr., Africa; Am., America; Aus., Australia; Eur., Europe; Med., Mediterranean.

APPENDIX 6.—Characteristics of prominent invaders in study area (cont.)

Plant name	Family	Origin	GF	W	LC	P	SR	VR	Disp. agent	Cult. use	VC
Pinus											
patula	Pinaceae	T (Am.)	t	woo	per	ev	seed		win	#silc, bar, orn	fo, gr
pinaster	Pinaceae	NT (Med.)	t	woo	per	ev	seed		win	#silc, bar	fy, fo
radiata	Pinaceae	NT (N Am.)	t	woo	per	ev	seed		win	#silc, bar	fy, fo
Populus											
alba	Salicaceae	NT (Eur., N Afr. & Asia)	t	woo	per	d		suc,cop	wat	silc, #bar, orn	sa, fo, gr, nk
deltoides	Salicaceae	NT (N Am.)	t	woo	per	d	seed	suc, cop	wat, win	#silc, agrc, orn	gr
nigra var. *italica*	Salicaceae	NT (Eur. & Asia)	t	woo	per	ev/d		suc, cop	wat	orn, #bar, c/b, agrc	gr
×*canescens*	Salicaceae	NT (Eur. & Asia)	t	woo	per	ev/d		suc, cop	wat	silc, #c/b, bar, orn	sa, fy, fo, gr, nk, sk
Prosopis											
glandulosa var. *torreyana*	Fabaceae	NT (N Am.)	t/s	woo	per	d	seed	cop	mam, wat	#agrc, orn	sa, nk, sk
velutina	Fabaceae	NT (N Am.)	t/s	woo	per	d	seed	cop	mam, wat	#agrc, orn	sa, nk, sk
Prunus persica	Rosaceae	NT. (Asia)	t	woo	per	d	seed	?cop	hum	#agrc, orn	gr
Psidium guajava	Myrtaceae	T (Am.)	t/s	woo	per	ev	seed	suc, cop	mam, bir, hum	#agrc, orn	sa, fo
Pyracantha											
angustifolia	Rosaceae	N Temp. (Asia)	s	woo	per	ev	seed	?cop	bir	orn, #bar	gr
coccinea	Rosaceae	N Temp. (Eur. & Asia)	s	woo	per	ev	seed	?cop	bir	orn, #bar	gr
crenulata	Rosaceae	NT (Asia)	s	woo	per	ev	seed	?cop	bir	orn, #bar	gr
Quercus robur	Fagaceae	NT (Eur. & Asia)	t	woo	per	d	seed	?cop	wat, ?mam (squirrels)	#orn, agrc	fy
Ricinus communis	Euphorbiaceae	T (Afr.)	t/s	woo	var	ev/d	seed	cop	wat, hum	#agrc, orn	sa, fy, fo, sk
Robinia pseudoacacia	Fabaceae	NT (N Am.)	t	woo	per	d	seed	suc, cop	wat, hum	orn, #c/b, bar, agrc	gr
Rosa rubiginosa	Rosaceae	NT (Asia)	s	woo	per	d	seed	?cop	mam, bir	#orn, bar, agrc	gr
Rubus											
cuneifolius	Rosaceae	NT (N Am.)	s	woo	per	ev/d	seed	suc, cop	bir	#agrc	sa, fo, gr
?*pascuus*	Rosaceae	NT (N Am.)	s	woo	per	ev/d	seed	suc, cop	bir	none	sa, gr
fruticosus	Rosaceae	NT (Eur.)	s	woo	per	ev/d	seed	suc, cop	bir	#agrc	sa, fy, fo, gr
×*proteus*	Rosaceae	hybrid origin (N Am. × S Afr.)	s	woo	per	ev/d	seed	suc, cop	bir	none	sa, gr
Salix											
babylonica	Salicaceae	NT (Asia)	t	woo	per	d		div	wat, hum	orn, #c/b, agrc	sa, fy, fo, gr, nk
fragilis	Salicaceae	NT (Eur. & Asia)	t	woo	per	d		div	wat, hum	orn, #c/b, ?agrc	gr
Salsola kali/tragus	Chenopodiaceae	NT (Eur. & Asia)	h	her	ann	germ	seed		win	none	nk
Schinus											
molle	Anacardiaceae	T (Am.)	t	woo	per	ev	seed	?cop	bir	#orn, bar	nk, sk
terebinthifolius	Anacardiaceae	T (Am.)	t/s	woo	per	ev	seed	?cop	bir	orn, #bar	fo
Senna didymobotrya	Fabaceae	T (Am.)	t/s	woo	per	ev	seed	?cop	wat, hum	orn, #bar	sa, fo
Sesbania punicea	Fabaceae	T (Am.)	t/s	woo	per	ev/d	seed		wat	#orn	sa, fy, gr
Solanum											
elaeagnifolium	Solanaceae	ST (S Am.)	h/s	sem	per	stems d	seed	rhz	?bir	none	nk
mauritianum	Solanaceae	T (Am.)	t/s	woo	per	ev	seed	cop	bir.	#orn	sa, fy, fo, gr
pseudocapsicum	Solanaceae	T (Am.)	h/s	sem	per	ev	seed	?cop	bir	#orn	fo
seaforthianum	Solanaceae	T (Am.)	c	her	per	ev/d	seed	cop	bir	#orn	sa, fo

Origin: ST, southern temperate, south of or straddling Tropic of Capricorn; NT, northern temperate, north of or straddling Tropic of Cancer; T, tropical, between or straddling Tropics of Capricorn and Cancer. GF, growth form: **t**ree; **t**ree/**s**hrub; **s**hrub; **h**erb; **h**erb/**s**hrub; **g**rass; **g**rass/**r**eed; **c**limber; **s**hrub/**c**limber.
W, woodiness: **woo**dy; **semi**-woody; **her**baceous; **suc**culent.
LC, life cycle: **per**ennial, **ann**ual, **var**iable, **bi**ennial.
P, perennation: **ev**ergreen; **d**eciduous; **ev**ergreen/**d**eciduous; **var**iable; **germ**inative.
SR, sexual reproduction: seed, spore.
VR, vegetative reproduction: **cop**pice; **suc**ker; **div**ision; rhz, rhizome; **bul**bil; **sto**lon; **tub**er; **run**ner.
Dispersal agent: **win**d; **wat**er; **bir**d; **mam**mal; **hum**an; ant.
Cultivated use: # primary (= major) use; **orn**amental; **bar**rier; **c**over/**b**inder; **agr**icultural **c**rop; **sil**vicultural **c**rop; none.
VC, vegetation category: **sa**vanna biome; **fy**nbos biome; **fo**rest habitats; **gr**assland biome; **nama-k**aroo biome; succulent **k**aroo biome.
Afr., Africa; Am., America; Aus., Australia; Eur., Europe; Med., Mediterranean.

APPENDIX 6.—Characteristics of prominent invaders in study area (cont.)

Plant name	Family	Origin	GF	W	LC	P	SR	VR	Disp. agent	Cult. use	VC
Tamarix chinensis	Tamaricaceae	NT (Asia)	t/s	woo	per	ev/d	seed	?cop	wat, win	#?orn, c/b, agrc	nk, sk
ramosissima	Tamaricaceae	NT (Eur. & Asia)	t/s	woo	per	ev/d	seed	cop, suc	wat, win	#?orn, c/b, agrc	nk, sk
Tithonia diversifolia	Asteraceae	T (Am.)	s	her	var	var	seed		?win	#orn	sa, fo
Xanthium strumarium	Asteraceae	T (Am.)	h	her	ann	germ	seed		wat, mam	none	sa, fo

Origin: ST, southern temperate, south of or straddling Tropic of Capricorn; NT, northern temperate, north of or straddling Tropic of Cancer; T, tropical, between or straddling Tropics of Capricorn and Cancer. GF, growth form: **t**ree; tree/**s**hrub; **s**hrub; **h**erb; **h**erb/**s**hrub; **g**rass; **g**rass/**r**eed; **c**limber; **s**hrub/**c**limber.
W, woodiness: **woo**dy; **sem**i-woody; **her**baceous; **suc**culent.
LC, life cycle: **per**ennial, **ann**ual, **var**iable, **bie**nnial.
P, perennation: **e**vergreen; **d**eciduous; **e**vergreen/**d**eciduous; **var**iable; **germ**inative.
SR, sexual reproduction: seed, spore.
VR, vegetative reproduction: **cop**pice; **suc**ker; **di**vision; rhz, rhizome; **bul**bil; **sto**lon; **tu**ber; **run**ner.
Dispersal agent: **wind**; **wat**er; **bird**; **mam**mal; **hum**an; ant.
Cultivated use: # primary (= major) use; **orn**amental; **bar**rier; **c**over/**b**inder; **agr**icultural **c**rop; **sil**vicultural **c**rop; none.
VC, vegetation category: **sa**vanna biome; **fy**nbos biome; **fo**rest habitats; **gr**assland biome; **n**ama-**k**aroo biome; succulent **k**aroo biome.
Afr., Africa; Am., America; Aus., Australia; Eur., Europe; Med., Mediterranean.

Bothalia 37,2: 249–258 (2007)

Seasonal variation in soil seed bank size and species composition of selected habitat types in Maputaland, South Africa

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Keywords: *Licuati*, Maputaland, Sand Forest, seed bank dynamics, Tembe Elephant Park, temporal variation, transient seed bank

ABSTRACT

Seasonal variation in seed bank size and species composition of five selected habitat types within the Tembe Elephant Park, South Africa, was investigated. At three-month intervals, soil samples were randomly collected from five different habitat types: a, *Licuati* forest; b, *Licuati* thicket; c, a bare or sparsely vegetated zone surrounding the forest edge, referred to as the forest/grassland ecotone; d, grassland; and e, open woodland. Most species in the seed bank flora were either grasses, sedges, or forbs, with hardly any evidence of woody species. The *Licuati* forest and thicket soils produced the lowest seed densities in all seasons. *Licuati* forest and grassland seed banks showed a two-fold seasonal variation in size, those of the *Licuati* thicket and woodland a three-fold variation in size, whereas the forest/grassland ecotone maintained a relatively large seed bank all year round. The woodland seed bank had the highest species richness, whereas the *Licuati* forest and thicket soils were poor in species. Generally, it was found that the greatest correspondence in species composition was between the *Licuati* forest and thicket, as well as the forest/grassland ecotone and grassland seed bank floras.

INTRODUCTION

The Maputaland Centre of Plant Endemism (Van Wyk 1996) is known as a centre of high species diversity, rich in endemic plant and animal species (Scott-Shaw 1999; Van Wyk & Smith 2001) and is as such recognized by the International Union for the Conservation of Nature (IUCN). A rare and unique vegetation type that is endemic to the Maputaland Centre of Plant Endemism is the Sand Forest (*Licuati* forest in Mozambique—Izidine *et al.* 2003) which houses a substantial number of floristic endemics. However, the survival of many of Maputaland's endemic plant species is threatened by the rapid expansion of the human population and the associated demand for firewood, building material, medicinal plants, as well as land for agriculture and cattle grazing (Lawes *et al.* 2004; Kyle 2004). Even in formal conservation areas, elephants (*Loxodonta africana*) and fire could potentially threaten the long-term survival of many species. It is therefore of the utmost importance that these biota-rich areas be conserved and managed properly.

To provide valuable information on the species composition of Maputaland's diverse vegetation, several phytosociological studies have been done in recent years (e.g. Kirkwood & Midgley 1999; Matthews *et al.* 2001; Gaugris *et al.* 2004), but little is known about the vegetation dynamics and functional ecology. This is especially true for the Sand Forest vegetation where active management strategies are essential to ensure the long-term survival of this vegetation type. Formulating successful strategies that will maintain the integrity of the Sand Forest, can only be achieved if they are based on a sound knowledge of the vegetation dynamics and functional ecology of the system.

Seed bank dynamics are an important aspect of the functional ecology of a vegetation type. Soil seed banks represent a pool of reproductive potential and a source of genetic inheritance and play an important role in vegetation establishment after a disturbance (Warr *et al.* 1993; Bakker *et al.* 1996). The absence of a soil seed bank has important consequences for the dynamics of a species or vegetation type, because in such cases the vegetation will not be able to regenerate from a soil-stored seed bank after a disturbance. A soil seed bank, however, is not a static entity and the seed density and species composition of the soil seed bank flora constantly vary in space and time (Thompson & Grime 1979; Roberts 1986; Milberg & Hansson 1993; Crawford & Young 1998; De Villiers *et al.* 2004).

The present study is the first to investigate the soil seed banks in Maputaland. The main focus was on the Sand Forest and its associated vegetation types. The objectives of the study were to compare the seasonal changes in the soil seed bank in terms of a, seed density and b, species composition across five different habitats in the Tembe Elephant Park in northern KwaZulu-Natal.

THE STUDY AREA

The Tembe Elephant Park (26° 51.56' S–27° 03.25' S and 32° 24.17' E–32° 37.30' E) lies in the core of the Maputaland Centre of Plant Endemism, is 30 013 ha in extent and encloses extensive areas of pristine, endemic Sand Forest as well as other woodland, grassland and wetland vegetation types (Moll 1980; Matthews *et al.* 2001).

Sand Forest, also known as *Licuati* forest in Mozambique (Izidine *et al.* 2003), occurs under more arid conditions than other southern African forest types (Moll 1977; Moll & White 1980; Ward 1981; Low & Rebelo 1998; Kirkwood & Midgley 1999). It shows clear links to the tropical forest of southern Africa but has a relict character and as such is characterized by a low rate of regeneration with few seedlings and saplings (Von Maltitz *et al.* 2003). The Sand Forest can be subdivided into two related vegetation types: *Licuati* forest

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MS. received: 2005-10-31.

(also often called Tall Sand Forest) and *Licuati* thicket (also referred to as Short Sand Forest). The *Licuati* forest, with canopy heights up to 20 m, is characterized by diagnostic tree species such as *Balanites maughamii, Cleistanthus schlechteri, Drypetes arguta, Newtonia hildebrandtii* and *Ptaeroxylum obliquum*, and little undergrowth is present (Matthews *et al.* 2001; Gaugris *et al.* 2004). *Licuati* thicket is a near-impenetrable, short stature forest type with canopy height less than 10 m (Matthews *et al.* 2001; Izidine *et al.* 2003; Gaugris *et al.* 2004). Diagnostic species in the thicket vegetation are *Croton pseudopulchellus, Hyperacanthus microphyllus, Psydrax fragrantissima* and *Ptaeroxylum obliquum*.

The *Licuati* vegetation often occurs as a mosaic with a very specific type of grassland which is dominated by grass species such as *Andropogon schirensis, Perotis patens, Pogonarthria squarrosa* and the forb *Tephrosia longipes* subsp. *longipes*. The transition between the *Licuati* vegetation and the grassland is abrupt and is represented by a bare or sparsely vegetated zone bordering the forest edge, dominated by *Perotis patens*. This transitional zone, which is only a few metres wide, is referred to as the forest/grassland ecotone in this study.

Several woodland types have been described for the Tembe Elephant Park ranging from sparse woodland, through open woodland to closed woodland. The open woodland, that was sampled for the seed bank study, is characterized by the geoxylic suffrutex *Salacia kraussii*, grasses such as *Aristida stipitata* subsp. *stipitata, Panicum maximum, Pogonarthria squarrosa,* and *Themeda triandra* and the tree species *Acacia burkei, Afzelia quanzensis, Albizia adianthifolia, Garcinia livingstonei, Strychnos madagascariensis, S. spinosa* and *Terminalia sericea* (Matthews *et al.* 2001; Gaugris *et al.* 2004).

The climate of Maputaland is characterized by hot, humid summers and cool, frost-free winters. According to weather data from the Sihangwane Weather Station in Tembe Elephant Park, the mean annual rainfall is 721 mm with a clear peak from October to April. The mean annual temperature for Tembe Elephant Park is 23.1°C, with absolute maximum and minimum temperatures of 45.0°C and 4.0°C (Gaugris *et al.* 2004).

METHODS

For the seed bank study, five different habitat types were selected in the southwestern part of the Tembe Elephant Park: a, *Licuati* forest; b, *Licuati* thicket; c, the forest/grassland ecotone; d, grassland; and e, woodland.

Sixty soil samples were collected within each of the five habitat types (5 × 60 samples) to determine the size and species composition of the soil seed bank. Soil sampling was carried out at three-month intervals for a period of 12 months. The top 100 mm of soil was collected with a soil auger with a diameter of 57 mm because an investigation into the depth distribution of seed in the seed bank revealed that most seeds were found in this layer (Kellerman 2004). The contents of the auger were emptied into a cotton soil-sampling bag and transported to the University of Pretoria. Soil samples which were used for the re-examination were stored in a dry, dark place at ambient temperatures until needed.

Samples were collected in January, April, July and September 2001, representing the summer, autumn, winter and spring soil seed bank, respectively. All soil samples were examined by the seedling emergence method immediately after collection. The results of this examination will be referred to as the seasonally germinable seed bank. The remaining soil of 15 randomly selected samples per habitat type was used in flotation studies (Kellerman 2004), and the remaining soil of the other 45 soil samples collected on one date per habitat type were subjected to a re-examination in September 2001. The rationale for the re-examination was, that if newly shed seeds had an after-ripening requirement, they would not germinate immediately after collection and would therefore not be detected by the seedling emergence method. By allowing an after-ripening period of a few months and re-examining duplicate samples in September, when temperatures were thought to be optimal for seed germination, the problem of an after-ripening requirement could be overcome. The results of this re-examination will be referred to as the persistent fraction of the soil seed bank. In arid regions where dormancy mechanisms are common for many species, such a re-examination indicates the size of the potentially-germinable seed bank (De Villiers *et al.* 2004).

The seedling emergence method was used to determine the seed bank size and species composition of each soil sample. Plastic pots (100 × 100 × 120 mm) were filled with finely ground quartz and topped with 100 cm^3 of soil from a sample. The pots (n = 60 per site per examination time) were placed in an uncontrolled greenhouse and watered daily with tap water and fortnightly with Arnon and Hoagland's complete nutrient solution (Hewitt 1952). Once a week, for a period of three months, all newly emerged seedlings were marked using toothpicks. Duplicate samples to determine the persistent seed bank fraction were investigated in the same manner in September 2001. Seedlings were identified as soon as possible and, once identified, removed from the pots to prevent contamination by self-seeding. Unidentified seedlings were left to mature for later identification. Voucher specimens are housed in the H.G.W.J. Schweickerdt Herbarium and nomenclature follows Germishuizen & Meyer (2003).

The percentage correspondence in species composition between the different habitat types and between the seasonally germinable and persistent fractions of the seed bank was calculated by means of Jaccard's Similarity Index (IS_J) which reads as follows:

$$IS_J = [c / (a + b + c)] \times 100$$

where c is the number of species common to both habitats or examination dates, a is the number of species restricted to one habitat or examination date, and b is the number of species restricted to the other habitat or examination date (Mueller-Dombois & Ellenberg 1974).

Data were analysed by using a one-way analysis of variance and Tukey's *post-hoc* test in the Statistica 7 computer program (Statsoft Inc., Tulsa, Oklohoma, USA).

RESULTS

Seed bank size

In general, the *Licuati* forest (Figure 1A) and *Licuati* thicket (Figure 1B) soils contained the smallest number of germinable seeds. Mean seed densities for the *Licuati* forest ranged from a low of 1 067 seeds m^{-2} in April to a high of 1 950 seeds m^{-2} in January and the *Licuati* thicket from 1 050 seeds m^{-2} in April to 3 200 seeds m^{-2} in January. In both cases the seasonal variation in seed bank size was statistically significant ($p = 0.013$ for *Licuati* forest; $p < 0.001$ for *Licuati* thicket). The *Licuati* forest and thicket seed banks showed a similar trend in seasonal variation in that they had the smallest seed numbers present in the soil during autumn, gradually increasing towards spring and reaching the highest seed densities in spring or summer. The *Licuati* thicket produced a significantly larger ($p < 0.001$) seed bank in summer than the *Licuati* forest, but seed bank size was similar in other seasons ($p > 0.05$ in all cases). When the *Licuati* forest soil samples were re-examined in spring, seed bank size was within 10% of that of the seasonally germinable seed bank. In the case of the *Licuati* thicket it was found that the autumn and winter seasonally germinable seed banks produced significantly larger seed numbers than the re-examination in spring ($p = 0.006$ for autumn comparison; 0.0008 for winter comparison), whereas the difference was not significant for the summer seed bank ($p < 0.001$).

In the forest/grassland ecotone, changes in the size of the seasonally germinable seed bank were damped ($p = 0.597$ over four seasons) (Figure 1C) and seed density ranged from 4 034 seeds m^{-2} in July to 4 667 seeds m^{-2} in September. When summer and winter collected soil samples were re-examined in spring, higher seed densities were encountered; however, these differences were not significant. The re-examined autumn soil samples yielded significantly less seeds ($p = 0.004$).

The seasonally germinable seed density of the grassland vegetation remained fairly constant from summer through autumn to winter, but showed a marked decline in spring ($p = 0.002$ over four seasons) (Figure 1D). The number of germinable seeds in the grassland soil almost halved from a high of 5 567 seeds m^{-2} in January to a low of 2 734 seeds m^{-2} in September. The seasonally germinable summer and autumn seed banks from the grassland soil produced significantly more seedlings than the duplicate analysis in spring ($p < 0.001$ for summer comparison; $p < 0.001$ for autumn comparison). This persistent fraction of the seed bank of the grassland soil remained relatively constant ($p = 0.897$) throughout the year.

Seasonal variation in seed densities in the woodland soils varied significantly ($p < 0.001$) and ranged from 2 167 seeds m^{-2} in September to 6 467 seeds m^{-2} in July. In contrast to the other vegetation types, the largest seasonally germinable seed bank in the woodland soils was present during winter (Figure 1E). The re-examination in spring produced significantly less seedlings than the seasonally germinable seed banks of all seasons ($p < 0.001$ for summer comparison; $p < 0.001$ for autumn comparison; $p = 0.039$ for winter comparison).

Species composition

In total, 52 genera and 83 taxa were identified in the soil samples, together with a few unidentified specimens (Appendices 1–5). Many seedlings died while still in the cotyledon stage before they could be positively identified. These unidentified seedlings are indicated in the tables as mortalities. In general, the *Licuati* forest and thicket seed banks had the lowest species richness per sampling time.

The largest number of taxa consistently emerged from the woodland seed bank. The highest number of taxa at a single sampling time was 35, recorded from the spring woodland soil seed bank. The re-examination of soil samples of the summer, autumn and winter collections in spring generally produced species richness counts either the same or less than the examination immediately after collection. However, the decrease in richness could be the result of the re-examination being based on 45 soil samples as opposed to 60 for the initial examination immediately after collection.

The seed bank flora of the *Licuati* forest and thicket differed vastly from those of the other three habitat types. Thirty-three taxa comprising nine grass, four sedge, 18 herbaceous and two woody species were identified in the *Licuati* forest seed bank (Appendix 1). The *Licuati* thicket soils produced 25 identified taxa including nine grass, four sedge and 12 other herbaceous species (Appendix 2). Diagnostic species of the *Licuati* forest and thicket seed banks included *Crassula* cf. *expansa, Cyperus dubius, Eragrostis* cf. *moggii, Leptochloa* cf. *uniflora* and *Panicum laticonum*. Only two woody species were encountered in the seed banks of the *Licuati* vegetation types. The seed bank flora was often dominated by a single species and seed densities in the *Licuati* forest seed bank ranged from 17 to 1 222 seeds m^{-2} for individual species at a particular sampling time and for the *Licuati* thicket from 17 to 2 822 seeds m^{-2}.

Floristic composition of the ecotone soil seed bank consisted of 45 taxa including 15 grass, six sedge, 23 herbaceous and one woody species (Appendix 3). The seed bank flora of the ecotone was dominated by the grass species *Perotis patens*, constituting 58.4% of the total number of seedlings. Other prominent species included *Bulbostylis burchellii, B. hispidula, Cyperus chersinus, Kohautia virgata, Phyllanthus* cf. *parvulus* and *Setaria sphacelata* var. *sphacelata*.

Thirty-six taxa comprising 14 grass, five sedge and 17 herbaceous species were recorded from the grassland soils (Appendix 4). Prominent species included *Bulbostylis burchellii, B. hispidula, Conostomium natalense, Digitaria eriantha, Eragrostis ciliaris, Kohautia virgata, Perotis patens, Pogonarthria squarrosa* and *Setaria sphacelata* var. *sphacelata*.

In the woodland soil seed bank the emergence of 61 species including 20 grass, seven sedge, 33 herbaceous and one woody species was recorded (Appendix 5). Prominent grass species obtained from the soil samples were *Aristida stipitata* var. *stipitata, Brachiaria chusque-*

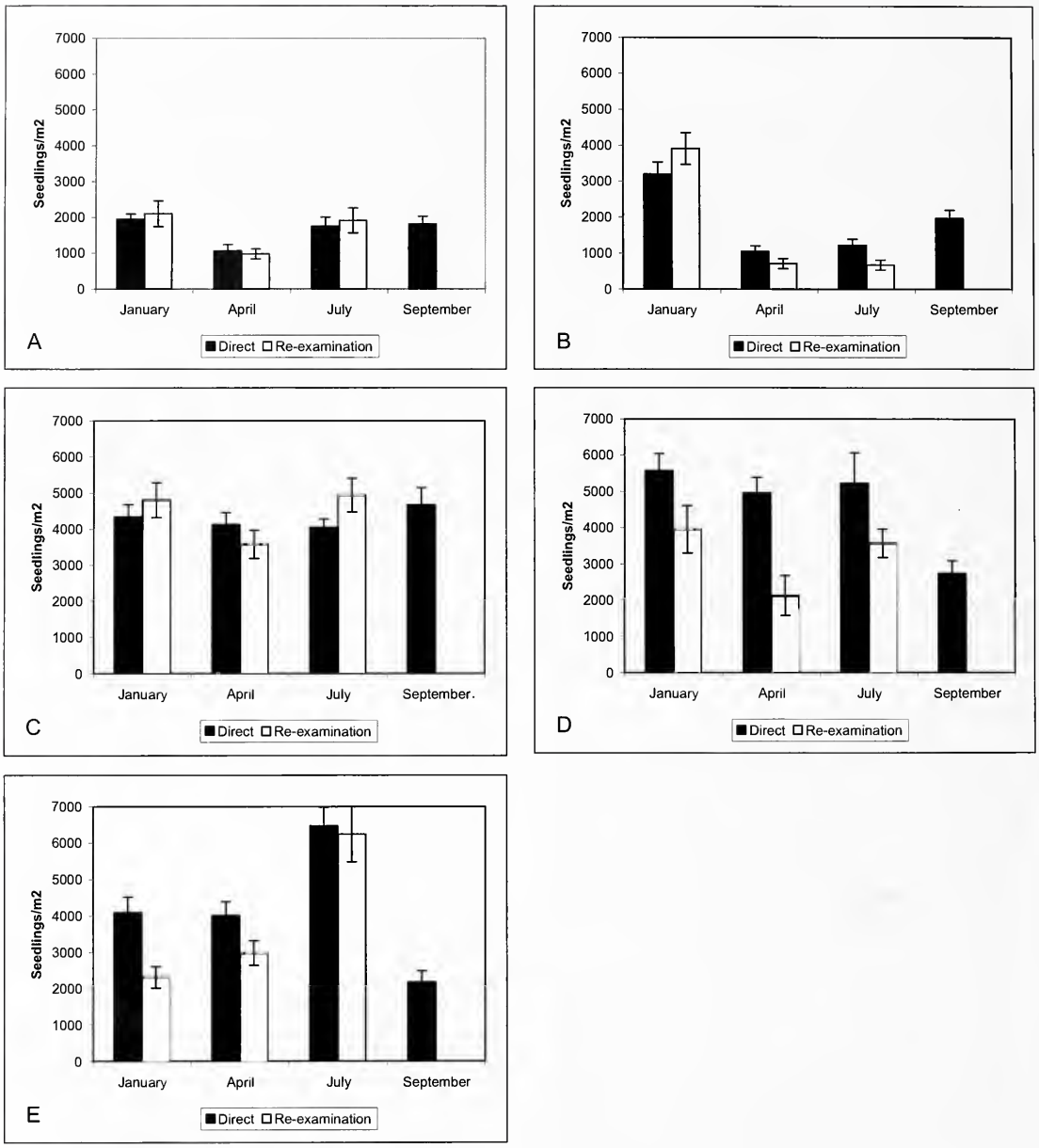

FIGURE 1.—Seed bank size (mean number of seeds m^{-2}) as obtained from soils collected in five selected habitat types in Tembe Elephant Park, when examined directly after collection, and re-examined in September. A, *Licuati* forest; B; *Licuati* thicket; C, forest/grassland ecotone; D, grassland; and E, woodland.

oides, Digitaria eriantha, Eragrostis ciliaris, Panicum maximum, Perotis patens, Pogonarthria squarrosa and *Setaria verticillata*. Other prominent herbaceous species recorded from the woodland seed bank soils were *Achyranthes aspera, Bulbostylis hispidula, Cyperus chersinus, Justicia flava, Kohautia virgata, Persicaria* cf. *decipiens* and *Phyllanthus parvulus*.

Species such as *Conyza albida, Gamochaeta pennsylvanica, Hypochaeris radicata, Oxalis* cf. *semiloba, Pseudognaphalium luteo-album* and *Sonchus asper* occurred in relatively large densities in the seed banks of all the investigated habitat types.

Jaccard's Similarity Index indicated a 62% correspondence in species composition between the *Licuati* forest and thicket seed banks (Appendix 6). The species composition of the forest/grassland ecotone and grassland seed banks also showed a high degree of similarity (58%, Appendix 6). There was a low correspondence of 29% between the *Licuati* forest and the forest/grassland ecotone in spite of their close spatial association. The woodland seed bank was more closely related to the grassland seed bank in composition than to the *Licuati* vegetation types. In general there was a low correspondence in species composition between the seasonally germinable seed bank and the re-examination in spring (Appendix 7).

DISCUSSION

Seed bank size

Several studies have indicated that forest seed banks are relatively small to almost nonexistent in both size and species richness (Warr *et al.* 1993; Crawford & Young 1998). Mature, dry, tropical forests generally produce very low seed bank densities and should there be higher seed numbers present in soils underlying dry forest vegetation, it could be ascribed to the abundant seed rain of pioneer species characteristic of early successional stages (Matlack & Good 1990; Alvarez-Buylla & García-Barrios 1991; Rico-Gray & García-Franco 1992; Faliñska 1998; Jankowska-Blaszczuk *et al.* 1998; Arévalo & Fernández-Palacios 2000; Guariguata 2000). Data from *Licuati* forest and thicket soils collected in the present study agreed well with these findings in that they produced the lowest seed densities of all the examined habitat types. Examples of mean seed densities obtained in other forest seed bank studies by the seedling emergence method include 265 to 2 910 seeds m^{-2} (Matlack & Good 1990), 203 to 5 613 seeds m^{-2} (Brown 1992), 330 to 3 437 seeds m^{-2} (Jankowska-Blaszczuk & Grubb 1997), 156 to 4 148 seeds m^{-2} (Faliñska 1998), 610 to 7 009 seeds m^{-2} (Halpern *et al.* 1999) and 137 to 6 920 seeds m^{-2} (Olano *et al.* 2002). Seed densities reported for the *Licuati* vegetation types (1 050 to 3 200 seeds m^{-2}) are in the same order of magnitude as those mentioned above for the other forest types. However, Kellerman (2004) warned that these values, obtained with the seedling emergence method, could have greatly underestimated the true size of the seed bank. The most noteworthy difference in the seed bank size between the *Licuati* forest and thicket vegetation types was that the *Licuati* thicket produced a significantly larger soil seed bank than the *Licuati* forest in summer. This could reflect differences in the floristic composition, reproductive strategies, timing of seed fall, seed germination requirements and seed dispersal efficiency between these two vegetation types.

Compared with the forest and woodland soils, the forest/grassland ecotone soil produced a large seed bank almost year round, implying that seasonal variation was of lesser significance. The same trend in temporal variation was observed in grasslands studied by Coffin & Lauenroth (1989), Milberg & Hansson (1993) and Kalamees & Zobel (1997). The grassland seed bank sampled in the Tembe Elephant Park only partly followed this trend being relatively constant for the largest part of the year, but showing a marked decline in spring. The persistent fraction of the seed bank of the grassland soil remained remarkably constant throughout the year. Mean seed density varied from 4 034 to 4 667 seeds m^{-2} in the forest/grassland ecotone and from 2 734 to 5 567 seeds m^{-2} in the grassland, which compares well with reported grassland seed densities of 122 to 2 748 seeds m^{-2} (Coffin & Lauenroth 1989), 2 580 to 10 060 seeds m^{-2} (Milberg & Hansson 1993) and 1 421 to 2 567 seeds m^{-2} (Kalamees & Zobel 1997). Seed bank studies of South African grasslands by O'Connor & Pickett (1992) and Adams (1996) found mean seed densities varying between 300 and 10 000 seeds m^{-2}.

The woodland seed bank differed from the forest/grassland ecotone and grassland seed banks in that it produced distinctly more germinable seeds in winter with greatly reduced seed densities observed in spring. Mean seed density varied from 1 734 to 6 467 seeds m^{-2}. Dougall & Dodd (1997) and García-Núñez *et al.* (2001) reported similar seed densities in their studies of neotropical savanna vegetation with mean seed densities of 897 to 9 100 seeds m^{-2}. The relatively smaller seed densities recorded from both the grassland and woodland soils in spring might have been the consequence of germination induced by early rainfall in September before the soil collection. Rainfall data for the Sihangwane Weather Station in Tembe Elephant Park for September 2001 was 22 mm, which would have been sufficient to trigger the germination of many seeds.

Species composition

Each habitat's seed bank was characterized by its own species composition although the *Licuati* forest and thicket seed banks showed a large degree of similarity, as did the forest/grassland ecotone and the grassland seed banks (62% and 58% respectively). The relatively low (29%) similarity between the *Licuati* forest and the forest/grassland ecotone stresses the abrupt transition in species composition from the forest to the surrounding edge. Species composition showed large seasonal variation within a specific habitat type. Thompson & Grime (1979), Roberts (1986) and Morgan (1998) drew similar conclusions. The largest similarity in species composition was found between the summer and autumn seed banks.

Dry, tropical forest types, such as the *Licuati* forest and thicket, are generally characterized by high species richness in the standing vegetation (Murphy & Lugo 1986; Swaine 1992; Matthews *et al.* 2001, Gaugris *et al.* 2004). However, tropical forest seed banks are usually very small or almost nonexistent and a large portion of the viable seeds that do occur in forest soils, belong to pioneer species (Roberts 1981; Thompson 1985; Rico-Gray & García-Franco 1992; Skoglund 1992; Bigwood & Inouye 1998; Jankowska-Blaszczuk *et al.* 1998). The similarity in species composition between the seed bank and the aboveground flora in the *Licuati* forest was reported to be only 7.8% (Kellerman 2004). An analysis of the floristic composition of both the *Licuati* forest and thicket soils showed that the soil seed bank was composed primarily of grasses, sedges, annuals and short-lived perennial species, supporting the evidence from other studies that dry, tropical forest climax species do not produce persistent seed banks.

It is generally believed that the Sand Forest is unable to regenerate after a major disturbance and this has led to many concerns about the long-term survival of this vegetation type. The lack of seeds of forest or thicket canopy species in the soil seed pool of these vegetation types could be one of the contributing factors why the *Licuati* vegetation does not regenerate readily after major disturbances. In the present study the seeds of the prominent canopy species were absent at all examination times, indicating that the seed bank of these species is either very short-lived or that the germination require-

ments of the seeds were not met by the seedling emergence method applied. If the seed banks of canopy species are transient, as most studies on forest seed banks seem to indicate, regeneration would have to depend on seed dispersal from undisturbed sites.

The re-examination of the forest and thicket soils revealed a few important trends. The summer seasonally germinable seed bank was dominated by weedy annual species such as species of *Conyza*, *Sonchus* cf. *asper, Gamochaeta pennsylvanica* and *Pseudognaphalium luteo-album*. These species apparently do not persist well in the seed bank, because their numbers were greatly reduced in the re-examination of duplicate samples in spring. In contrast, the re-examined samples were dominated by other species e.g. *Leptochloa* cf. *uniflora* (*Licuati* forest) and *Panicum laticonum (Licuati* thicket). These grass species dominating in the spring re-examination apparently require some after-ripening to break seed dormancy.

The seasonally germinable seed bank of the forest/grassland ecotone was dominated by the grass species *Perotis patens* and sorrel *Oxalis* cf. *semiloba*. In the grassland seed bank, the relative contributions of the species differed among seasons. The most important species in the seasonally germinable seed bank were *Bulbostylis hispidula, Conyza albida, Oxalis* cf. *semiloba* and *Sonchus* cf. *asper*. The re-examination in spring of both the ecotone and grassland soils showed an increase in the seed density of *Perotis patens*, indicating that the seeds of this species require some after-ripening for optimal germination. A study to investigate the similarity between the seed bank and aboveground flora found a 44.4% similarity for the grassland (Kellerman 2004). This value is substantially higher than that of the *Licuati* thicket.

The woodland vegetation in the Tembe Elephant Park is composed of an upper tree layer and a prominent herbaceous or grass layer. The woodland soils examined in this study produced the highest number of species. Interesting though, was that the woodland soils produced the highest richness from the smallest seed density as was observed from the spring seed bank data. Despite the large number of species, only one woody species was recorded from the woodland soil seed bank.

In conclusion, with the exception of the forest/grassland ecotone, the seed banks of all habitat types investigated in this study, showed pronounced seasonal variation. The *Licuati* forest and *Licuati* thicket seed banks had the lowest seed densities and also the lowest species richness. In general, grass and sedge species comprised more than 40% of the seed bank flora that emerged from the soil samples. The remaining species were mostly annual and perennial forbs, with hardly any evidence of woody species.

ACKNOWLEDGEMENTS

The authors thank Ezemvelo KwaZulu-Natal Wildlife (EKZNW) for the opportunity to do this study in the Tembe Elephant Park and Wayne Matthews of EKZNW for his assistance and valuable advice. The material is based on research supported by the National Research Foundation (GUN 2053522).

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APPENDIX 1.—Seasonal variation in seed density (mean number of seeds m^{-2}) of species in *Licuati* forest seed bank when examined directly (Dir.) after collection and re-examined (Re.) in September

Species	Jan.		Apr.		Jul.		Sep.	Species	Jan.		Apr.		Jul.		Sep.
	Dir.	Re.	Dir.	Re.	Dir.	Re.	Dir.		Dir.	Re.	Dir.	Re.	Dir.	Re.	Dir.
Ancylobotrys petersiana	17							*Digitaria eriantha*						22	
Aristida stipitata subsp. *graciliflora*	17							*Eragrostis* cf. *moggii*	33						
Brachiaria chusqueoides				22				*Euphorbia inaequilatera*	17				17	67	
Clerodendrum glabrum var. *glabrum*		67						*Gamochaeta pennsylvanica*	183	67	117	89	17	22	17
Conostomium natalense					17			*Gisekia pharnacioides* var. *pharnacioides*		22					100
Conyza albida	667	178	167	67			100	*Helichrysum acutatum*			50				
C. canadensis	33		83		17			*H.* cf. *silvaticum*		67					
Crassula cf. *expansa*		67			17			*Hypochaeris radicata*	17	22	17				
Cyperus austro-africanus	17							*Leptochloa* cf. *uniflora*	183	1222	33	400	567	1067	750
C. dubius		22		44	17	22		*Nidorella* cf. *resedifolia*		17			17		
C. macrocarpus				22											
C. zollingeri	33			44	300	533	17	*Oxalis* cf. *semiloba*	83	200	33	178	450	44	517

APPENDIX 1.—Seasonal variation in seed density (mean number of seeds m^{-2}) of species in *Licuati* forest seed bank when examined directly (Dir.) after collection and re-examined (Re.) in September (cont.)

Species	Jan.		Apr.		Jul.		Sep.
	Dir.	Re.	Dir.	Re.	Dir.	Re.	Dir.
Panicum deustum			17				
P. laticonum			317	22		111	33
Perotis patens		22			33		
Persicaria cf. *decipiens*							17
Phyllanthus cf. *parvulus*					17		17
Pseudognaphalium luteo-album	150		17		33		33
Pteridophytes		22					
Setaria verticillata				22			50
Solanum macrocarpon				22			
Sonchus cf. *asper*	117	44	133				17
Unknown species					17		
Mortalities	383	67	83	44	217	22	150
Total	1950	2106	1067	978	1750	1911	1817

APPENDIX 2.—Seasonal variation in seed density (mean number of seeds m^{-2}) of species in *Licuati* thicket seed bank when examined directly (Dir.) after collection and re-examined (Re.) in September

Species	Jan.		Apr.		Jul.		Sep.
	Dir.	Re.	Dir.	Re.	Dir.	Re.	Dir.
Brachiaria chusqueoides				22			200
Conyza albida	583	111	183	44	17		83
Conyza canadensis	317						
Crassula cf. *expansa*		22				22	
Cyperus chersinus							17
C. dubius		67					
C. macrocarpus		44					17
C. zollingeri	17	89	17	44	33		133
Digitaria eriantha		22					
Eragrostis cf. *moggii*	33		17			22	
Euphorbia inaequilatera					50	67	
Gamochaeta pennsylvanica	17		133	22	117		117
Hypochaeris radicata	100		100	22			
Leptochloa cf. *uniflora*	117	356	33	67	383	178	
Nidorella cf. *resedifolia*					17		
Oxalis cf. *semiloba*		200	100	311	217	44	483
Panicum deustum			17				
P. laticonum	1350	2822	33	111	67	133	583
Perotis patens		22		22		111	50
Pseudognaphalium luteo-album	83				200		
Pteridophytes		22					
Setaria sphacelata var. *sphacelata*				22			
S. verticillata							17
Sida cordifolia							17
Sonchus cf. *asper*	117	22	283				17
Unknown species					17		
Mortalities	467	111	133	22	100	89	233
Total	3200	3912	1050	712	1217	667	1967

APPENDIX 3.—Seasonal variation in seed density (mean number of seeds m^{-2}) of species in forest/grassland ecotone seed bank when examined directly (Dir.) after collection and re-examined (Re.) in September

Species	Jan.		Apr.		Jul.		Sep.
	Dir.	Re.	Dir.	Re.	Dir.	Re.	Dir.
Aristida stipitata subsp. *graciliflora*	17		67				33
Brachychloa schiemanniana					17	67	
Bulbostylis burchellii	167	378	67	200	200	644	367
B. hispidula	200		167		50		317
B. parvinux		600		133		289	
Conostomium natalense		44					
Conyza albida	633	22	183	89	33	22	167
C. canadensis			50				
Cyperus chersinus	100	156		133	50		67
C. indecorus var. *inflatus*		22	150		33		50
C. zollingeri		22		22		22	
Digitaria didactyla					17		
D. eriantha					33		
Eragrostis cf. *chloromelas*					17	44	
E. ciliaris	133			22			
Euphorbia inaequilatera					83		
Gamochaeta pennsylvanica	217	22	67	67	117		433
Helichrysopsis septentrionale					17		
Helichrysum acutatum					33		
H. cf. *silvaticum*						22	
H. kraussii	17						
H. sp.							17
Hypochaeris radicata	150		83				50
Kohautia virgata	33	178	133	378	67	178	100
Kyphocarpa angustifolia					17		
Leptochloa cf. *uniflora*		22					
Nidorella cf. *resedifolia*						22	
Oxalis cf. *semiloba*		200	983	89	1400	133	250
Panicum cf. *repens*							17
P. maximum						22	
Perotis patens	783	2533	633	2089	1467	2711	2033
Persicaria cf. *decipiens*		22		44	17		
Phyllanthus cf. *parvulus*	33	44	17	44		22	50
Poa annua	17						17
Pogonarthria squarrosa						133	
Pseudognaphalium luteo-album	300	44	17				
Senna cf. *petersiana*						22	
Setaria sphacelata var. *sphacelata*		422		178	17		183
S. verticillata				44		22	
Sida cordifolia					17		17
Solanum macrocarpon	17						
Sonchus cf. *asper*	333		750		150		
Tamarix species							17
Tephrosia multijuga							17
Trachypogon spicatus					17		
Unknown species					67		
Mortalities	1183	67	750	44	100	556	467
Total	4333	4800	4117	3578	4034	4934	4667

APPENDIX 4.—Seasonal variation in seed density (mean number of seeds m^{-2}) of species in grassland seed bank when examined directly (Dir.) after collection and re-examined (Re.) in September

Species	Jan.		Apr.		Jul.		Sep.
	Dir.	Re.	Dir.	Re.	Dir.	Re.	Dir.
Andropogon gayanus							17
Aristida stipitata subsp. *graciliflora*		89		22	17		33
Brachychloa schiemanniana		22				22	
Bulbostylis burchellii	117	600		511	300	733	300
B. hispidula	617		433		450		300
B. parvinux		244		289		133	17
Chloris virgata	67					44	
Conostomium natalense		178	50	22	17		
Conyza albida	783		167	22	50	89	17
C. canadensis	17		17				
Cyperus chersinus					17		
C. indecorus var. *inflatus*			17			22	33
Digitaria didactyla			17		17		
D. eriantha	100				67		
Eragrostis cf. *chloromelas*					17		
E. ciliaris	50						33
E. inamoena							17
Euphorbia inaequilatera					17	89	17
Gamochaeta pensylvanicum	167	67	17	156	317		17
Helichrysum cf. *silvaticum*		22					33
Hypochaeris radicata	500		400		33	67	17
Justicia flava	17						17
Kohautia virgata	617	1133	117	1400	1117	644	850
Nidorella cf. *resedifolia*					17	22	
Oxalis cf. *semiloba*	17	333	1283	156	2033	89	17
Perotis patens	233	978	267	822	467	1378	783
Persicaria cf. *decipiens*			17				
Phyllanthus cf. *parvulus*				22			
Poa annua							17
Pogonarthria squarrosa	17		17	44	17	311	
Pseudognaphalium luteo-album	250						
Setaria sphacelata var. *sphacelata*		222				22	33
S. verticillata				22			
Solanum sp. nov.							17
Sonchus cf. *asper*	283		950	22			
S. cf. *oleraceus*	150						
Unknown species					33		
Mortalities	1567	67	1183	44	200	67	150
Total	5567	3956	4950	3556	5217	3734	2734

APPENDIX 5.—Seasonal variation in seed density (mean number of seeds m^{-2}) of species in woodland seed bank when examined directly (Dir.) after collection and re-examined (Re.) in September

Species	Jan.		Apr.		Jul.		Sep.
	Dir.	Re.	Dir.	Re.	Dir.	Re.	Dir.
Achyranthes aspera					100	111	183
Aristida stipitata subsp. *graciliflora*	117	133	167			133	
Becium filamentosum				933			17
Brachiaria chusqueoides						44	83
Brachychloa schiemanniana		22		22			
Bulbostylis burchellii		67	17			44	
B. hispidula	33		33		33		17
B. parvinux				44		22	
Clerodendrum glabrum var. *glabrum*				22			
Commelina benghalensis						44	50
Conyza albida	600	22	217	22	17	22	17
C. bonariensis		22					
C. canadensis	17		50				50
Crassula cf. *expansa*							17
C. cf. *obovata*							17
C. sp.		22	17				
Cucumis metuliferus	17						
Cyperus austro-africanus		22			17		83
C. chersinus	67	111	133	222	133	111	17
C. dubius		67		22			
C. zollingeri			33				83
Digitaria didactyla					17		
D. eriantha		156	50	89	17	467	33
Eclipta prostrata							33
Eragrostis cf. *chloromelas*							67
E. cf. *curvula*					17		
E. cf. *gummiflua*					17		
E. ciliaris	67	200	17				433
E. inamoena						22	
Euphorbia cf. *helioscopia*							17
Gamochaeta pennsylvanica	250	222	150	378	717	111	67
Helichrysum cf. *silvaticum*		44			17		
H. kraussii			17		133	133	
Hypochaeris radicata	67		117				17
Justicia flava	33		17	22	117	156	17
Kohautia virgata	350	578	250	378	667	1333	67
Momordica balsamina	17		17				17
Nidorella cf. *resedifolia*		44		44	350	67	33
Oxalis cf. *obtusa*							17
O. cf. *semiloba*	17	44	1167		1150	378	33
Panicum deustum					33		
P. cf. *repens*	183		217				
P. laticonum				22			
P. maximum	17		17	67	450		83
Perotis patens			267	22	17	89	
Persicaria cf. *decipiens*	17	22	33	22		22	

APPENDIX 5.—Seasonal variation in seed density (mean number of seeds m^{-2}) of species in woodland seed bank when examined directly (Dir.) after collection and re-examined (Re.) in September (cont.)

Species	Jan.		Apr.		Jul.		Sep.
	Dir.	Re.	Dir.	Re.	Dir.	Re.	Dir.
Phyllanthus cf. *parvulus*	250	133	83	67	83	111	117
P. sp. nov.	50	67	33	22			
Pogonarthria squarrosa	67			422	67	378	
Pseudognaphalium luteo-album	367	22	33				
Setaria sphacelata var. *sphacelata*		22		111	1533	2244	50
S. verticillata	50	133			67	44	33
Sida cordifolia	33			22			
Sonchus cf. *asper*	233		400				17
S. cf. *oleraceus*	17						
Sporobolus panicoides							33
Tephrosia multijuga							17
Tragus berteronianus	17						
Wahlenbergia cf. *undulata*							33
Xanthium strumarium							50
Unknown species							83
Mortalities	1133	133	450		700	156	167
Total	4084	2312	4000	2979	6467	6244	2167

APPENDIX 6.—Jaccard's Similarity Index (%) in total species composition of soil seed banks of vegetation types in Tembe Elephant Park

	LF	LT	F/G	G	W
Licuati Forest	100	62	29	33	32
Licuati Thicket		100	33	31	32
Forest/Grassland Ecotone			100	58	45
Grassland				100	43
Woodland					100

LF, *Licuati* Forest; LT, *Licuati* Thicket; F/G, Forest/Grassland Ecotone; G, Grassland; W, Woodland.

APPENDIX 7.—Jaccard's Similarity Index calculated between direct examination of soil samples and their re-examination in spring

	Similarity (%)		
	Jan.	April	July
Licuati Forest	27	29	38
Licuati Thicket	29	54	31
Forest/Grassland Ecotone	33	33	22
Grassland	22	42	38
Woodland	25	31	50

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OBITUARY

IAN FREDERICK GARLAND (1925–2007)

Ian Frederick Garland (Figure 1) was born on 20 March 1925 in Verulam, north of Durban. He attended the Verulam and Cordwalles Primary Schools and Michaelhouse High School.

Ian arrived at Twinstreams, his sugar farm, in Mtunzini in October 1945, 'when the stream banks were well wooded and protected and the valley bottoms were stable wetlands. Crystal clear water flowed out of papyrus swamps and swamp forests and in November the vleis were yellow with *Eulophia* orchids'. An all round naturalist, he became a life member of the Natal Society for the Preservation of Wildlife in 1947 and was chairman of that pioneer society when it joined the National Society and became the Natal Branch in 1954. He later edited the monthly bulletin and wrote a natural history column for many years. He was among the first sugar farmers to realise the environmental damage that is caused by the practice of draining inland and coastal wetlands for agricultural exploitation and set about establishing a restoration project on the Siyayi Catchment that served as a demonstration area. In his retirement, he propagated and planted out about 40 000 trees in a huge reclamation project.

Eve Palmer, author of the ground-breaking three-volume study, *Trees of southern Africa* (1972), paid great tribute to Ian Garland in the chapter on *To build a book*: 'In Zululand, a fermenting passion of interest in trees burst into these pages. It was that of Ian Garland of 'Twinstreams', Mtunzini, sugar farmer by profession and naturalist by choice. He supplied most of the specimens and some of the photographs of Zululand trees and much of the information on them—their uses, their place in magic and medicine, and their Zulu names'. Furthermore, it 'was Ian Garland who, in pursuit of material for this book, collected, for the first time in South Africa, *Commiphora zanzibarica*, and many other rarities'.

Ian was listed as ornithologist on the famous Tongaland (Maputaland) Expedition of 1947. This expedition, 'an important scientific survey of Tongaland' attracted attention around the country and the world. It was a remote and little known corner of South Africa at that time. The members of the expedition included leading specialists and produced reports on birds, mammals, fish and flora.

Ian Garland had formed a close partnership with Jobe Mafuleka (Figure 2), whose ancestral home was in Sihangwane Forest near the Pongola floodplain in the far north of Maputaland. In Ian's own words 'Jobe is a wonderful companion and teacher and has been responsible for most of my knowledge about the trees of Maputaland and their uses. He has been my friend, teacher and adviser for over forty years' (Garland 1994). There will be a number of botanists who will recall expeditions with Ian and Jobe along winding, deep, white sandy tracks exploring the great sand forests of Maputaland, turning up many new species and new distribution records.

He was at the forefront of the cultivation of indigenous plants in the summer rainfall area. He had over 350 species of trees in his arboretum at Twinstreams and his nursery would form a centre for the propagation for the University of Zululand Indigenous Plant Use Programme. Over the years he set up a nursery with an extensive list of trees and shrubs and many flowering herbs too. The delightful little *Pelargonium tongaense* was one of his introductions. *Raphia australis*, *Monodora junodii*, *Craibea zimmermannii*, *Albizia zuluensis*, *Ficus trichopoda*, *Croton pseudopulchellus*, *Croton steenkampianus*, *Pteleopsis myrtifolia* and many other Maputaland species were popularized by Ian. Ever the enthusiast, his mission was to get people interested and involved, selling the plants was never important! He inspired many an indigenous grower and gardener over

FIGURE 1.—Ian Frederick Garland (1925–2007).

FIGURE 2.—Ian Garland and Jobe Mafuleka botanizing at Kosi Bay.

FIGURE 3.—Ian Garland on the granite dome overlooking Ngoye Forest, sharing his knowledge with a group of plant enthusiasts.

more than 50 years. He was a great gift giver—of plants, fruit and, most generously, of his time.

As long ago as the 1950s he established an environmental educational facility called Mick's Park at Twinstreams. It has inspired generations of people, young and old, including teacher training courses and groups from the Wilderness Leadership School and African Conservation Education (ACE). All this was in addition to Ian's farming and family commitments! Today Mick's Park is run as a project of the Wildlife and Environment Society, with Mondi Forests, providing more formal accommodation for school groups.

Ian's most lasting legacy, the extent of which it is almost impossible to calculate, was to inspire a passion for the natural world and for plants in particular. There is surely hardly a field botanist in the country who has not at some stage been in the field with Ian—either at Twinstreams, exploring the coastal dunes, dune forest, swamp forest and wetlands—or his beloved Ngoye (Figure 3) and the other great Zululand forests, as well as Tongaland/Maputaland. He knew his plants intimately, in every season, and their place in the larger scheme of things—the birds, animals, insects and other life forms, including people, with which they were associated—and he shared this knowledge generously.

Hilliard & Burtt (1991) said '*Dierama sertum* (the adjective *sertum* means 'garland'), is named in honour of Mr Ian Garland of Mtunzini, whose name will always be associated with conservation in Zululand; he was with us on all three occasions that we collected the plant, at Ngoye and on his farm at Mtunzini, and he and Mrs Garland kindly sent material to Mrs Batten for illustration'. He and his wife Jean's hospitality was legendary.

Ian Garland received his M.Sc. at the University of Natal in 1971, his D.Sc. in 1995, and D. Philosophy at the University of Zululand in 1997. He was much honoured in his lifetime, as the Wildlife Conservationist of the Year (1982), and was awarded the Sugar Association Gold Medal (1990), Botanical Society Flora Conservation Gold Medal (1990), Wildlife Society Gold Medal (1991), and the S.A. Nature Foundation (WWF) Gold Medal (1995).

He is survived by Jean and his five children, Bill, Francie, Peter, Ruth and Jilly and their families.

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Bothalia 37,2: 261–282 (2007)

South African National Biodiversity Institute: administration and research staff 31 March 2007, publications 1 April 2006–31 March 2007

Compiler: B.A. Momberg

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Conradie, Ms J.K. Monitoring and Reporting Manager
Driver, Ms A.L. B.Soc.Sci.(Hons), M.A., M.B.A. Deputy Director. Planning, monitoring and advice
Smith, Ms T.J. Ph.D. Bioregional Projects Officer

BIODIVERSITY, KRC—CAPE TOWN (DBIO/C)

Roberts, R. B.Sc.(Hons). SIBIS Manager (contract worker)
Rogers, Ms I.M. Supervisor: data ecoding and georeferencing (contract worker)
Sink, Dr K.J. Ph.D.(Zool.). Marine Programme Co-ordinator (contract worker)

BIODIVERSITY PLANNING—PRETORIA (DBIO/PL)

Rouget, M.J.F. Ph.D. Biodiversity Planning Manager. Alien plant invasions, conservation planning

Jonas, Ms Z.R. M.Sc.(Conserv. & GIS). Conservation Planner
Mbona, Ms N. B.Sc. (student)
Mohamed, Ms B.M. B.Sc.(Hons). GIS Conservation Planner for TSP
Wistebaar, Ms P.N. B.Sc.(Hons)(Applied remote sensing & GIS). Conservation Planner

EASTERN CAPE CO-ORDINATION UNIT—PORT ELIZABETH (DBIO/EC)

Cadman, M.J. Ph.D. Bioregional Programmes Co-ordinator: Eastern Cape (contract worker)
Hartmann, N.R. B.Sc.(Hons)(GIS). Intern Project Officer (contract worker)

BIODIVERSITY GIS (BGIS)—CAPE TOWN (DBIO/BC)

Cocks, M. M.Sc.(Bot.).Web Developer (contract worker)
Khatieb, Ms S. B.Sc.(Hons). GIS Technician (contract worker)
Van Ross, G.M. B.Com.(Hons), N.Dip.(Public Admin.). BGIS Assistant Project Manager (contract worker)

THREATENED SPECIES PROGRAMME—PRETORIA (DBIO/TS)

Foden, Ms W.B. M.Sc.(Cons. Biol.). Programme Manager

Agenbag, Ms L. B.Sc.(Hons). Red List Officer (contract worker)
Manyama, P.A. Intern (contract worker)
Matlamela, P. Intern (contract worker)
Victor, Ms J.E. M.Sc.(Plant Syst.), H.Dip.(Journ.). Control Agricultural Scientist. Red List Scientist. Taxonomy of Rutaceae, Asclepiadaceae

CUSTODIANS OF RARE AND ENDANGERED WILD FLOWERS (CREW)
THREATENED PLANT PROJECT (DBIO/CR)

Raimondo, Ms D.C. M.Sc.(Cons. Biol.). National Programme Manager (Pretoria)

Ebrahim, I. N.Dip.(Hort.). Custodians of Rare and Endangered Wildflowers Programme (CREW). Co-ordinator (Cape Town) (contract worker)
Jacobs, L.E.O. Data Encoder. Cape Town (contract worker)
Marimuthoo, Ms D. B.Sc.(Hons). CREW Co-ordinator (Pietermaritzburg) (contract worker)
Parbhoo, Ms S. B.Sc.(Microbial Biotechnology). Co-ordinator (Pretoria) (contract worker)
Von Witt, Ms C.G. Project Assistant: Cape Floristic Region (contract worker)

SUCCULENT KAROO ECOSYSTEM PROGRAMME (SKEP)—CAPE TOWN (YDBR/SK)

Willoughby, S.W. M.A.(Geogr. Sci.). Project Manager (contract worker)

Johnson, Ms M. M.Admin. Programme Manager (contract worker)
Hartney, Ms D.J. B.A.(Hons)(Envir. & Geogr. Sci.). Project Developer (contract worker)
Mathys, Ms C.L. N.Dip.(Journ.).Communications Officer (contract worker)
Williams, Mrs B. Dip.(Admin.). Programme Administrator (contract worker)

NATIONAL GRASSLANDS BIODIVERSITY PROGRAMME—PRETORIA (YDBR/GG)

Nazare, Ms F.C. M.Sc. Programme Co-ordinator (contract worker)

CAPE ACTION PLAN FOR PEOPLE (CAPE) PROJECT

CAPE TOWN

Sandwith, T.S. M.Sc.(Cons.Biol.), HED. Programme Co-ordinator (contract worker)

Barnett, M. Ph.D. Programme Developer (contract worker)
Court, Ms S.J. N.Dip.(Computer Admin.). Finance Manager (contract worker)
Damons, Ms M.H. B.A.(Dev. & Env.). Project Officer (contract worker)
Manuel, J.J. B.Sc.(Hons). Land Use Advisor (contract worker based at DEA & DP)
Martin, Ms F. Provisioning Admin. Clerk I (contract worker)
Parker, Mrs A. B.A.(Hons). Project Developer (contract worker)
Sotashe, Ms N. B.Bibl. Fynbos i-Forum Library Intern (contract worker based at UCT)

GARDENS DIRECTORATE—ADMIN STAFF (GDIR)

PRETORIA

Willis, C.K. M.Sc.(Cons. Biol.). Chief Director: Gardens and Horticultural Services

Bagus, Mrs J. N.Dip.(Account.). Senior State Accountant. Poverty Relief Projects (contract worker)
Els, Ms L. N.Dip.(Sec.). Senior Secretary IV

CAPE FLATS NATURE PROJECT—CAPE TOWN (APRJ/UC) (GDIR/CF)

Goldman, Ms T. B.Soc.Sci.(Hons). Project Manager
Hathorn, Ms P.M. B.A.(Hons), N.Dip.(Hort.). Capacity building Manager
Martin, Ms M. Cert.Masters Business Serv.(CMBS). Control Provincial Admin. Clerk

URBAN CONSERVATION UNIT—CAPE TOWN (APRJ/UC) (GDIR/CF)?

Davis, G.W. Ph.D. Deputy Director: Urban ecology. Communications

Peter, L.M. N.Dip.(Hort.). Principal Communications Officer. Communications Manager. Edith Stevens Reserve
Phoswayo, Ms V. Cert. Office Admin. Senior Provisioning Admin. Clerk II. Admin. support (contract worker)

INTERPRETATION—PRETORIA (GINN)

Ferreira, Ms L. B.A.(Fine Art), N.Dip.(Nature Cons.). Chief Auxiliary Services Officer. Information

BUILDING PLANNING, MAINTENANCE & DEVELOPMENT—CAPE TOWN (BPMD)

Linde, D.C. N.T.C.III(Civil & Structural: Building), N.T.C.III (Inspector of Works: Building), M.S.A.I.D, Cert. Estate Agency. Control Works Inspector

Abrahams, P. Handyman. Building maintenance
Manasse, S.P. Dip.(Masonry). Artisan Foreman. Building maintenance
Peck, W.I. Senior Handyman. Building maintenance
Tomlinson E.C. Handyman. Building maintenance

CURATORS

Behr, Ms C.M. Curator: Pretoria NBG
Britz, R.M. Curator: Lowveld NBG (Nelspruit)
Gavhi, M.P. Curator: Free State NBG (Bloemfontein)
Hankey, A.J. Acting Curator: Walter Sisulu NBG (Roodepoort/Mogale City)
Le Roux, P.H. Deputy Director. Curator: Kirstenbosch NBG (Cape Town)
Oliver, I.B. Curator: Karoo Desert NBG (Worcester)
Tarr, B.B. Curator: Natal NBG (Pietermaritzburg)

HAROLD PORTER NBG—BETTY'S BAY (GHPG)

Carolus, Ms B.J. B.Tech.(Hort.). Chief Agricultural Development Technician. Garden management. Acting Curator

Arendse, L.P. Senior Provisioning Clerk I.
Bebe, Ms N. Cleaner I
Bezuidenhout, Mrs H.M. Chief Provisioning Admin. Officer
Floris, Ms C. Auxiliary Services Officer II. Access control
Forrester, Ms J.A. N.T.C.III(Hort.). Chief Agricultural Development Technician. Garden management
Hendricks, C.H. (student)
Leon, J.S. (student)
Malgas, E.K. Senior Foreman. Garden maintenance and development
October, Ms R.P. Dip.(Ed.). Senior Auxiliary Services Officer. Plant records and admin. support
Smith, E.J. Senior Foreman. Estate maintenance and development
Theunissen, Ms C.J. Auxiliary Services Officer II. Access control
Van Wyk, A.B. Artisan. General maintenance

KAROO DESERT NBG—WORCESTER (GKAR)

Oliver, I.B. N.Dip.(Hort.), N.Dip.(Parks & Recrea. Admin.), N.Parks Dip. (Parks & Recrea. Managem.). Control Agricultural Technician. Curator

Harris, Ms S. N.Dip.(Hort). Chief Agricultural Development Technician. Scientific collections
Kwayimani, P. N.Dip.(Hort.). Chief Agricultural Development Technician. Garden management
Makubalo, F.N. Principal Foreman. Nursery
Mpeke, Ms E.N. Specialist Cleaner
Sekgobela, M.B. B.Tech.(Nature Cons.). Interpretation
Sibozo, N.E. Driver II. Plant sales
Simani, D.K. Principal Foreman. Plant collections
Van der Westhuizen, Ms M. Specialist Cleaner
Viljoen, D.M. N.Dip.(Hort.). Chief Agricultural Development Technician. Records Officer

KIRSTENBOSCH NBG—CAPE TOWN (GKBC)

Le Roux, P.H. Dip.(Forestry), N.Dip.(Hort.), N.Dip.(Parks & Recrea. Managem.), Cert.Turf Management. Deputy Director: Garden Management. Curator
Poole, Ms F.Y. N.Dip.(Public Managem. & Admin.). Assistant Director: HR management

Adams, T.D. B.Tech.(Hort.). Chief Agricultural Development Technician. Supervisor: Greenhouse
Hitchcock, A.N. N.H.Dip.(Hort.). Control Agricultural Development Technician. Nursery Manager
Morkel, A.T. N.Dip.(Nature Cons.). Control Agricultural Development Technician. Estate Manager
Notten, Ms A.L. B.Sc., N.Dip.(Hort.). Chief Agricultural Development Technician. Interpretive Officer
Van Wyk, F. Artisan. Supervisor: Workshop

Adonis, A. Principal Foreman. Dell & ericas
Adonis, S.J. Senior Foreman. Alien vegetation control
Arends, Ms S.J. Principal Auxiliary Services Officer. Plant records
Bolani, Ms J.L. Buchu collection (student)
Brown, B.M. N.Dip.(Hort.). Agricultural Development Technician. Seed room
Crowie, R.W. Principal Foreman. General garden
Emms, P.I. N.Dip.(Hort.), B.Sc.(Hons). Kirstenbosch Scholar 2006 (contract worker)
Duncan, G.D. M.Sc., N.Dip.(Hort.). Control Agricultural Development Technician. Bulbs, systematics of *Lachenalia*
Engelbrecht, F. Senior Provisioning Admin. Clerk II. Stores
Engelbrecht, Mrs L.D. Control Auxiliary Services Officer. Plant records
Grace, T. Senior Provisioning Admin. Clerk III. Stores & admin. support
Gudlindlu, D. Intern Nature Conservation (contract worker)
Harrower, A.D. B.Sc.(Bot. & Zoo.) Ball Agreement. Project Manager
Haynie, R.D. Senior Handyman. Workshop
Hope, C.F. Senior Handyman. Construction
Jacobs, H.C. Principal Foreman. Plant production
Jansen, K.J. Principal Foreman. Drivers
Jodamus, Ms N.L. N.Dip.(Hort.). Chief Agricultural Development Technician. Annuals, Rutaceae, alpines and Cape endemics
Julie, V. Control Specialist Groundsman. Proteas
Kayster, G.J. Principal Foreman. Construction
Kuscus, G.W. Principal Foreman. General maintenance
Mathys, Mrs S.S.B. Senior Accounting Clerk III. Revenue and garden statistics
Mbambezeli, N.G. N.Dip.(Hort). Agricultural Development Technician. Trees & shrubs
Mitchells, G. Control Specialist Groundsman. Senior Foreman. Casual staff projects
Newman, W. Artisan. Mechanical workshop
Nyati, L.G. (student)
Petersen, A.D. Control Specialist Groundsman. Cycads
Picane, Ms S. Auxiliary Services Officer II. Tissue culture
Prins, F.B. Security Officer III
Rudolph, A. Security Officer III
Shanks, G.R. Ball Agreement. Glass House Assistant (contract worker)
Skepe, M.M. Senior Foreman. Proteas
Smith, Mrs A. Senior Provisioning Admin. Clerk II. Admin. support
Smith, D. Accounting Clerk II. Seed room
Solomons, T.C. Senior Security Officer II
Tamboer, J.S. Principal Foreman. Index nursery
Twine, Ms M. N.Dip. Chief Agricultural Development Technician. Proteas & restios
Van der Walt, Mrs L.E. N.Dip.(Hort.). Chief Agricultural Development Technician. Herbaceous collections (part time)
Van Gusling, E.J. Principal Foreman. Mowers
Van Jaarsveld, E.J. M.Sc., N.Dip.(Hort.). Control Agricultural Technician. Succulents
Van Reenen, D.B. Principal Auxiliary Services Officer. Label maker
Viljoen, Ms C.C. N.Dip.(Hort.). Chief Agricultural Development Technician. Plant production
Voigt, W.E. N.Dip.(Hort.). Chief Agricultural Development Technician. Dell
Wall, Ms K.E. (student, 2nd year)
Wigget, J.N. (student)
Xulubana, L. (student, 2nd year)

VISITORS CENTRE—CAPE TOWN (GKBC/VC)

Struys, Ms S. B.A.(Hons)(Directing), Postgrad.Dip.(Market. Manag.). Assistant Director: Communication. Events & Centre Manager

Fredericks, Ms N.C.E. Senior Auxiliary Services Officer. Information services
Jacobs, A.P. Chief Auxiliary Services Officer. Information services
Malan, Ms C.E. B.Sc.(Hons). Principal Communication Officer: Tour co-ordinator
Pekeur, Ms A.B. Control Provisioning Administration Clerk II: Events Co-ordinator
Phillips, R. Senior Provisioning Admin. Clerk. Facilities Officer
Williams, G.C. Senior Auxiliary Services Officer. Information

LOWVELD NBG—NELSPRUIT (GLOW)

Britz, R.M. N.Dip.(Forestry). Control Agricultural Technican. Curator

Froneman, W.C.F. N.T.C.III(Hort.), N.Dip.(Nature Cons. & Man.), N.Dip.(Parks & Rec. Admin.). Control Agricultural Technician. Nursery management & garden development

LOWVELD NBG (cont.)

Hurter, P.J.H. B.Sc.(Hons). Control Agricultural Technician. Garden Manager. Cycad conservation
Khoza, Ms P.K. Cleaner I
Le Roux, Ms L. N.H.Dip.(Nature Cons.). Chief Auxiliary Services Officer. Interpretation
Makamo, Ms J.E. Cleaner II
Maqungo, Ms V.L.B. Auxiliary Services Officer. Front line Officer
Mathebula, Ms I.N. Senior Auxiliary Services Officer. Front line Officer
Mathebula, Ms N.R. Senior Accounting Clerk I. Admin. Support
Mlombo, Ms T.C. Senior Foreman. Garden
Ndlovu, L.D. Principal Foreman. Artisan
Ngwenya, P.S. Senior Auxiliary Services Officer II. Kiosk
Nyathikazi, Ms T.P. Senior Auxiliary Services Officer. Admin.
Shongwe, V.P. Foreman. Garden
Sibanyoni, Ms S.M. Specialist Cleaner II
Van der Walt, Ms K. N.Dip.(Nature Cons.). Horticulturist. Threatened Plants Project
Xozumti, M.M. Principal Foreman. Supervisor. Garden

KWAZULU-NATAL NBG—PIETERMARITZBURG (GKZN)

Tarr, B.B. N.Dip.(Parks & Recrea. Admin.), Advanced Dip.(Adult Educ.). Control Agricultural Technician. Curator

Dlungwane, T.R. Principal Foreman. Developement & maintenance
Johnson, Ms I. HED, M.Sc. Control Agricultural Development Technician
Khanyile, P.S. Cert.(Basic IT concepts, MSWord, Excell & PowerPoint). Interpretation
Nonjinge, S.H.B. N.T.C.III(Hort.). Chief Agricultural Development Technician
Shozi, B.V. (Hort. student)
Sibiya, Ms C.P.T. Cleaner II
Van der Merwe, Mrs M.E.H. Senior Provisioning Admin. Clerk III
Zimu, M.J. Principal Foreman. Horticulture maintenance

FREE STATE NBG—BLOEMFONTEIN (GFSG)

Gavhi, M.P. N.Dip.(Hort.). Control Agricultural Technician. Curator

Barnard, Ms A.D. B.A.(Personnel Managem.). Senior Provisioning Admin. Clerk III (part time)
Lepitla, M.H. Senior Foreman. Garden
May, T.S. Foreman. Garden
Mogorosi, Ms R.K. Hort Intern (contract worker)
Nene, A.G. N.Dip.(Hort.). Agricultural Development Technician. Garden management
Ngcobo, Ms B.P. Hort Intern (contract worker)
Ngalo, M.S. Senior Auxiliary Services Officer. Interpretation
Nyuleka, Ms N.A. Senior Accounting Clerk I
Raditlhare, Mrs E.M. Specialist Cleaner
Rambuwani, L.D. N.Dip.(Hort.). Chief Agricultural Development Technician. Nursery
Sebolai, Ms C.L. Specialist Cleaner

PRETORIA NBG (GPTA)

Behr, Ms C.M. B.Sc.(Hons). Control Agricultural Development Technician. Curator

Baloyi, K.J. Senior Auxiliary Services Officer II. Information Officer. Garden records
Keyter, B.A. Senior Security Officer II
Kutama, B.T. Principal Foreman. Garden: hard landscape development and maintenance
Lithudza, E.F. Dip.(Hort.). Chief Agricultural Development Technician
Mabapa, Ms K.I. Cleaner II
Mahlangu, J.F. Senior Foreman. Garden: machine operators and irrigation
Mahlangu, R.E. Cert.(Office Admin.), Cert.(Plater.). Senior Artisan. Workshop and general maintenance
Makgobola, Ms M.R. Auxiliary Services Officer II. Reception & admin. Support
Mkhasibe, Mrs N.S. Dip.(Office Admin.). Senior Provisioning Admin. Clerk I. Leave records and H.R. support
Modisha, M.D. Cleaner II
Mukondelcli, T.E. Senior Provisioning Admin. Officer
Naidoo, D.A. N.Dip.(Hort.), Dip.(Fund & Managem.). Control Agricultural Development Technician
Radebe, C.A. N.Dip.(Hort.). Senior Agricultural Development Technician
Schiel, A. Cert.(Plaster). Artisan. Building construction development and maintenance
Sibiya, Ms T.R. Cleaner II
Singh, Mrs R. Senior Provisioning Admin. Clerk III. Admin. support
Solomons, Ms C.V. Principal Auxiliary Services Officer. Plant records clerk

WALTER SISULU NBG—ROODEPOORT (GSIS)

Hankey, A.J. N.Dip.(Hort.), B.Tech.(Hort.). Control Agricultural Development Technician. Garden, estate, collections, nursery. Acting Curator

Aubrey, Mrs A.E. B.Tech.(Hort.). Chief Agricultural Development Technician. Plant records, interpretation, information (part time)
Baloyi, S.J. Handyman. Stores
Dlamini, M.D. N.Dip.(Hort.). Chief Agricultural Development Technician. Garden, nursery
Head, Mrs S.E. Dip.(Shorthand & Typing). Provisioning Admin. Officer
Mabela, H.L. B.Tech.(Hort.). Agricultural Development Technician. Nursery, collections
Mamosebo, M.A. Factotum
Manyikana, T.M. Factotum
Masithi, K. Hort. Intern (contract worker)
Mmola, Mrs B.E. Cleaner II
Mtsweni, P. N.Dip.(Hort.). Senior Agricultural Development Technician. Support services, estate
Ndou, A.P. Senior Auxiliary Services Officer II. Information services
Ndzondo, Ms N.L. Senior Provisioning Admin. Clerk I
Ndzondo, Mrs P.G. Cleaner II
Nedambale, M.P. Senior Foreman. Garden and nursery
Nemalili, M.E. Senior Foreman. Machines and vehicles
Nenungwi, M.S. Senior Foreman. Nursery

RESEARCH DIRECTORATE (RDIR)

PRETORIA

Smith, Prof. G.F. Ph.D., F.L.S. Chief Director: Biosystematics Research and Biodiversity Collections
Marais, Mrs A.C. Senior Provisioning Admin. Officer. Personal Assistant

Arnold, T.H. Head: Data Management (Pretoria)
Crouch, Prof. N.R. Head: Ethnobotany Unit (Durban)
Donaldson, Dr J.S. Director: Kirstenbosch Research Centre (Cape Town)
Klopper, Mrs R.R. M.Sc. Senior Plant Taxonomist. Taxonomy of Asphodelaceae and Pteridophyta (Pretoria)
Koekemoer, Dr M. Curator: National Herbarium (Pretoria)
Meyer, Mrs N.L. B.Sc.(Hons). Agricultural Development Technician (contract worker)
Roux, Dr J.P. Curator: Compton Herbarium (Cape Town)
Singh, Ms Y. Curator: Natal Herbarium (Durban)
Wolfson, Dr M.M. Director: Research Support Services

KWAZULU-NATAL HERBARIUM—DURBAN (RHED)

Singh, Ms Y. HED, M.Sc. Deputy Director. Taxonomy of Araceae, Hypoxidaceae. Curator

Apollos, Mrs C.E. Senior Provisioning Admin. Clerk II. Marketing
Glen, H.F. Ph.D. Specialist Scientist. Taxonomy of trees, cultivated plants; botanical history
Hlongwane, Mrs N.C. Specialist Cleaner & messenger
Magubane, M.M. Dip.(Agric.). Field work Supervisor. Zulu Botanical Knowledge Project (contract worker)
Ngwenya, M.A. Chief Agricultural Development Technician. Herbarium Officer. Plant identification and information, Zulu Botanical Knowledge Project
Mazibuko, J.V.G. Senior Auxiliary Services Officer. Herbarium Assistant
Noble, Mrs H-E. Chief Provisioning Admin. Clerk III

ETHNOBOTANY UNIT—DURBAN (RETH)

Crouch, Prof. N.R. Ph.D. Deputy Director. Ethnobotany of southern African flora, bioprospecting

NATIONAL HERBARIUM—PRETORIA (RHEN)

Koekemoer, Ms M. Ph.D. Deputy Director. Herbarium management. Taxonomy of Asteraceae: Gnaphalieae
Rampho, Ms E.T. B.Sc. Deputy Curator

Bredenkamp, Mrs C.L. Ph.D. Control Agricultural Scientist. Assistant Curator: Public relations. Taxonomy of *Vitex*, *Passerina,* Malvaceae, Sterculiaceae, and other related families
Fish, Mrs L. B.Sc. Principal Agricultural Scientist. Assistant Curator: Collections Manager. Taxonomy of Poaceae

NATIONAL HERBARIUM (cont.)

Herman, P.P.J. M.Sc. Control Agricultural Scientist. Assistant Curator: Personnel. Taxonomy of Asteraceae

Mothogoane, M.S. Chief Auxiliary Services Officer. Assistant Curator: Herbarium assistants. Wing C

Sebothoma, P.N. Cert.Sec. Principal Auxiliary Services Officer. Assistant Curator: Service room. Plant identifications co-ordinator

Van Rooy, J. Ph.D. Control Agricultural Scientist. Assistant Curator: Technical staff. Taxonomy and biogeography of mosses

Anderson, J.M. Ph.D. Specialist Scientist. Molteno Palaeoflora, Gondwana Alive

Archer Mrs C. M.Sc. Principal Agricultural Scientist. Taxonomy of Cyperaceae, monocotyledons (general)

Archer, R.H. Ph.D. Control Agricultural Scientist. Taxonomy of mainly Celastraceae, Euphorbiaceae

Bester, S.P. M.Sc. Principal Agricultural Scientist. Taxonomy of Apocynaceae, Ericaceae, Rutaceae

Burgoyne, Ms P.M. M.Sc. Control Agricultural Scientist. Mesembryanthemaceae and Crassulaceae

Götzel, Ms A. Senior Provisioning Admin. Clerk III

Govender, Ms M. B.Sc. Senior Agricultural Development Technician. Curation and plant ID in Wing C

Jordaan, Mrs M. M.Sc. Principal Agricultural Scientist. Taxonomy of Celastraceae: Celastroideae, interactive key to the trees of southern Africa

Kgaditsi, T.W. Senior Auxiliary Services Officer. Specimen mounter, general assistant

Krige, Ms A. B.Sc. Principal Agricultural Scientist.

Makgakga, M.C. B.Sc. Agricultural Development Technician. Curation and plant ID in Wing B

Makgakga, K.S. Principal Auxiliary Services Officer. Herbarium Assistant. Encoding plant specimens, data capturing, labels typist, curation of Wing D

Makholela, Ms T.M. Ph.D. Principal Agricultural Scientist. Taxonomy of Acanthaceae and Rubiaceae

Maserumule, M.K. Principal Auxiliary Services Officer. Curation of Wing B

Mashua, Ms T.J. B.Sc.(Microb.Biotechnol.). Scientific Officer. Gondwana Programme (contract worker)

Masombuka, Ms A.S. N.Dip.(Nature Cons.). Principal Auxiliary Services Officer. Herbarium Assistant. Curation of Wing A

Meyer, J.J. HED. Chief Agricultural Development Technician. Bioprospecting Project

Mnengwane, Ms J.J.J. B.Sc. Senior Scientific Officer. Wing D

Moeaha, Ms M.J. Senior Herbarium Technician. Poaceae Project (contract worker)

Mothapo, M.A. H.Cert.Off.Admin.(DMS). Herbarium Assistant: Principal Auxiliary Services Officer. Data Capturer, encoding, plant loans & gift exchanges

Mothapo, Ms N. B.Sc.(Hons)(Zool.). Scientific Officer. Gondwana Programme (contract worker)

Mudau, Ms A.C. B.(Envir.Sci.). Scientific Officer (contract worker)

Nkoane, Ms G.K. Principal Auxiliary Services Officer. Loans, exchanges, gifts, parcelling, stores

Phahla, T.J. Senior Auxiliary Services Officer. Specimen mounter of cryptogams, packer, general assistance

Phephu, Ms N. B.Sc.(Hons). Senior Agricultural Development Technician. Mosses

Ready, Mrs J.A. N.Dip.(Hort.). Principal Auxiliary Services Officer. Plant identifications, *Helichrysum*. Curation of Wing D

Retief, Ms E. Ph.D. Principal Agricultural Scientist. Taxonomy of Boraginaceae, Verbenaceae, Lamiaceae, Asteraceae, Rubiaceae, Geraniaceae, Oxalidaceae, Vitaceae

Sachse, Ms B. B.Sc.(Hons). Senior Agricultural Development Technician. Herbarium information

Smithies, Mrs S.J. M.Sc., Dip.Ed.(Moray House). Chief Agricultural Development Technician. Taxonomy of Scrophulariaceae *sens. lat.*, Pedaliaceae, Bignoniaceae, Lentibulariaceae, Gesneriaceae, Martyniaceae, Orobanchaceae

Steyn, Ms C.C. Principal Auxiliary Services Officer. Scientific support

Swelankomo, Ms N. B.Sc.(Hons). Senior Agricultural Development Technician. Curation and plant ID in Wing D

Welman, Ms W.G. M.Sc. Principal Agricultural Scientist. Taxonomy of Dipsacaceae, Solanaceae, Cucurbitaceae, Asteraceae: *Helichrysum*, Senecioneae

Winter, P.J.D. M.Sc. Principal Agricultural Scientist. Taxonomy of mainly Apiaceae

DATA MANAGEMENT—PRETORIA (RPDC)

Arnold, T.H. M.Sc. Principal Data Technologist. Assistant Director. Computer database application especially in taxonomy

Boman, Ms M.J. PRECIS data typist

Botha, Mrs A.G. Chief Auxiliary Services Officer. Administrative Assistant

De Wet, Mrs B.C. B.Sc.(Comp. Sci.), B.A., H.D.L.S. Principal Agricultural Datametrician. Chief PRECIS programmer (contract worker)

Montshonyane, Ms E.M. Senior Herbarium Assistant: API medicinal plants (contract worker)

Mostert (née Joubert), Mrs R.E. B.Sc.(Hons). Agricultural Scientist. PRECIS Information Officer

Snyman, Mrs E.E. B.Sc. N.Dip.(Comp. Data Proc.). Senior Agricultural Development Technician. PRECIS Information Officer

Steenkamp, Ms Y. M.Sc. Principal Agricultural Scientist. PRECIS Information Co-ordinator

Steyn, Ms H.M. Senior Agricultural Scientist. PRECIS Information Officer

Walters, Ms M. M.Sc.(Conserv.Ecol.). Scientific Officer. API medicinal plants (contract worker)

RESEARCH SUPPORT SERVICES—PRETORIA (EDIR)

Wolfson, Mrs M.M. Ph.D. Director. HDE Policy and Legislation related to Access and Benefit-sharing, Bioprospecting and Intellectual Property
Mutizhe, Ms L.S. Senior Secretary IV. Personal Assistant

Liebenberg, Mrs E.J.L. Head: Research Support Services, Publications
Potgieter, Mrs E. Principal Librarian
Ramatlo, Ms N. N.Dip.(Sec.). Senior Secretary IV
Van Wyk, E. Project manager, Millenium Seed Bank Project

PUBLICATIONS—PRETORIA (RPUB)

Liebenberg, Mrs E.J.L. M.Sc. Control Agricultural Technician. Cytotaxonomy. Manager

Chiliza, S.B. Senior Herbarium Assistant. Botanical artist (contract worker)
Condy, Ms G.S. M.A. Chief Industrial Technician. Botanical artist
Du Plessis, Mrs E. B.Sc.(Hons), S.E.D. Chief Language Practitioner. Technical editor. Editing, translating, layout
Fouché, Ms E. M.A:(Corporate Communication & Graphic Design). Graphic design
Germishuizen, G. M.Sc. Assistant Director. Scientific Editor
Leistner, O.A. D.Sc. F.L.S. Agricultural Scientist (contract worker)
Mapheza, T.P. Senior Provisioning Admin. Clerk III. Bookshop Manager
Momberg, Mrs B.A. B.Sc.(Entomol. & Zoo.). Principal Language Practitioner. Technical editor. Editing, layout (part time)
Maree, Ms D.J. HED. Senior Computer Operator.
Sithole, A.M. Provisioning Admin. Clerk II. Bookstore
Turck, Mrs S. B.A.(Information Design). Control Industrial Technician. Graphic design

MARY GUNN LIBRARY—PRETORIA (RLBP)

Potgieter, Ms E. B.Libr. Principal Librarian
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1 April 2006–31 March 2007

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Bothalia 37,2: 283–293 (2007)

Guide for authors to *Bothalia*

This guide is updated when necessary and includes an index. **Important points and latest additions appear in bold type.**

Bothalia is named in honour of General Louis Botha, first Premier and Minister of Agriculture of the Union of South Africa. This house journal of the South African National Biodiversity Institute (SANBI), Pretoria, is devoted to the furtherance of botanical science. The main fields covered are taxonomy, ecology, anatomy and cytology. Two parts of the journal and an index to contents, authors and subjects are published annually.

1 Editorial policy

1.1 *Bothalia* welcomes original papers dealing with flora and vegetation of southern Africa and related subjects. Full-length papers and short notes, as well as book reviews and obituaries of botanists, are accepted. The editor should be notified that an article is part of a series of manuscripts; please submit a list of the parts of a series; all parts should preferably be published in one journal.

1.2 Submission of a manuscript to *Bothalia* implies that it has not been published previously and is not being considered for publication elsewhere.

1.3 Authors whose first language is not English are requested to have their MS edited by an English speaker before submission.

1.4 Articles are assessed by referees, both local and overseas. Authors are welcome to suggest possible referees to judge their work. Authors are responsible for the factual correctness of their contributions. *Bothalia* maintains an editorial board (see title page) to ensure that international standards are upheld.

1.5 **Page charges:** as stated in our notification included in volume 23,1 (May 1993), MSS submitted for publication in *Bothalia* are subject to payment of page charges of R125,00 per printed page, VAT included. The following are exempt from these charges: 1, SANBI members; 2, persons/institutions who have been granted exemption by the Executive Committee of the SANBI; 3, authors of contributions requested by the Editor; 4, contributors to the column '*FSA* contributions'. The Editor's decision on the number of pages is final. An invoice will be sent to the author, who must arrange for payment as soon as possible to SANBI, Publications Section, Private Bag X101, Pretoria 0001.

1.6 Deadline dates for submission of MS: for possible inclusion of the MS for the May issue—August of the previous year, and for the October issue—March of the same year.

2 Requirements for a manuscript

2.1 The original manuscript should be typed on one side of A4-size paper, double line spacing throughout (including abstract, tables, captions to figures, literature references), and have a margin of at least 30 mm all round. **Tables should be typed in single line spacing on a separate page at the end of the article.** Three photocopies (all pages photocopied on both sides of the paper, including figures, to reduce weight for postage) of all items, including text, line drawings, tables and lists should be submitted, and the author should retain a complete set of copies. **Three photographs (or high quality photocopies) of each figure should be submitted for review purposes. The electronic version of the text and the figures should be submitted with the manuscript.**

2.2 Papers should conform to the general style and layout of recent issues of *Bothalia* (from volume 26 onwards).

2.3 Material should be presented in the following sequence: title page with title, name(s) of author(s), keywords, abstract (and information that should be placed in a footnote on the title page, such as address(es) of author(s) and mention of granting agencies).

2.4 The sequence continues with Introduction and aims, Contents (see 8), Material and methods, Results, Interpretation (Discussion), Specimens examined (in revisions and monographs), Acknowledgements, References, Index of names (recommended for revisions dealing with more than about 15 species), Tables, Captions for figures and figures. In the case of short notes, obituaries and book reviews, keywords and an abstract are superfluous.

2.5 All pages must be numbered consecutively beginning with the title page to those with references, tables, captions for figures and figures.

2.6 Special characters: use your own word or code that is unique and self-explanatory, enclosed between ANGLE BRACKETS, e.g. <mu>m for µm. Please supply us with a list of the codes.

2.7 Use a non-breaking space (in MS Word—Ctrl, shift, space) to keep two elements together on the same line, e.g. 3 500.

2.8 DO NOT JUSTIFY LINES.

2.9 Do not break words, except hyphenated words.

2.10 A **hyphen** is designated as one dash, with no space between the letter and the dash, e.g. ovate-lanceolate. See also 17.6.

2.11 An **N-dash** is typed in MS Word code (alt + 0150) or as **three** hyphens with no space between the letter and the hyphen, e.g. 2- - -5 mm (typeset, it looks like this, 2–5 mm). See also 17.6.

2.12 An **M-dash** is typed in MS Word code (alt + 0151) or as **two** hyphens with no space between the letter and the hyphen, e.g. computers- -what a blessing! (typeset, it looks like this: computers—what). See also 17.6.

2.13 Do not use a double space anywhere between words, after commas, full stops, colons, semicolons or exclamation marks.

2.14 Use lower case x as times sign, with one space on either side of the x, e.g. 2 x 3 mm.

2.15 Use single (not double) opening and closing quotes, e.g. the so-called 'stiffy' refers to a rigid diskette. In MSWord the codes are alt + 0145 and alt + 0146.

2.16 Keys—put only three leader dots before number of taxon (with one space before and after each dot), regardless of how far or near the word is from the right margin, e.g. . . . 1. *R. ovata* (see 13.18).

3 **Requirements for diskettes/electronic files**

3.1 **USE NORMAL STYLE ONLY.**

3.2 **Electronic files can be provided on CD or sent via the e-mail to momberg@sanbi.org or germishuizen@sanbi.org.**

3.3 Data must be in **MSWord.** An rtf file is preferable because it retains the formatting.

3.4 All lines, headings, keys, etc., should start flush at the margin, therefore NO INDENTATIONS, FOOTNOTES, TABS OR STYLES of any kind.

3.5 In MS Word, italics and bold should be used where necessary.

3.6 Paragraphs and headings are delineated by a carriage return (ENTER) but **no indentation**.

3.7 **Graphics i.e. drawings, graphs or photographs: submit in a separate file, do not include it in the text.**

3.8 Image files with a bigger file size than **2MB** cannot be e-mailed as the SANBI has a **2MB** limitation on the network's firewall at Head Office. Files smaller than 2MB can be emailed to: **momberg@sanbi.org**.

3.9 If any image file was originated in CorelDraw up to version 12 or Adobe Illustrator **up to version CS 2,** please provide the image file as a CDR file (please include fonts). The conversion to TIF or other file extensions will be accommodated by the SANBI (see 12.2–12.4).

3.10 If extensive changes to image files are proposed by the editor, the author will be contacted and the specific image file will have to be re-submitted after the indicated corrections have been implemented.

3.11 **Tracked changes must not be included when submitting a MS on a CD or electronically.**

4 **Author(s)**

When there are several authors, the covering letter should indicate clearly which of them is responsible for correspondence and, if possible, telephonically available while the article is being processed. The contact address, telephone number and email address should be mentioned if they differ from those given on the letterhead.

5 **Title**

The title should be as concise and as informative as possible. In articles dealing with taxonomy or closely related subjects, the family of the taxon under discussion (see also 13.2) should be mentioned in brackets but author citations should be omitted from plant names (see also 13.6).

6 **Keywords**

Up to 10 keywords (or index terms) should be provided in English in alphabetical sequence. The following points should be borne in mind when selecting keywords:

6.1 Keywords should be unambiguous, internationally acceptable words and not recently coined little-known words.

6.2 They should be in a noun form and verbs should be avoided.

6.3 They should not consist of an adjective alone; adjectives should be combined with nouns.

6.4 They should not contain prepositions.

6.5 The singular form should be used for processes and properties, e.g. evaporation.

6.6 The plural form should be used for physical objects, e.g. augers.

6.7 **Location** (province and/or country); taxa (species, genus, family) and vegetation type (community, veld type, biome) should be used as keywords.

6.8 Keywords should be selected hierarchically where possible, e.g. both family and species should be included.

6.9 They should include terms used in the title.

6.10 They should answer the following questions:

6.10.1 What is the *active concept* in the document (activity, operation or process).

6.10.2 What is the *passive concept* or object of the active process (item on which the activity, operation or process takes place).

6.10.3 What is the means of accomplishment or how is the active concept achieved (technique, method, apparatus, operation or process).

6.10.4 What is the environment in which the active concept takes place (medium, location).

6.10.5 What are the independent (controlled) and dependent variables?

6.11 Questions 6.10.1 to 6.10.3 should preferably also be answered in the title.

7 **Abstract**

7.1 Abstracts of no more than 200 words should be provided. Abstracts are of great importance and should convey the essence of the article.

7.2 They should refer to the geographical area concerned and, in taxonomic articles, mention the number of taxa treated. They should not contain information not appearing in the article.

7.3 In articles dealing with taxonomy or closely related subjects all taxa from the rank of genus downwards should be accompanied by their author citations (see also 13.6).

7.4 Names of new taxa and new combinations should not be italicized but put in bold. If the article deals with too many taxa, only the important ones should be mentioned.

8 Table of contents

A table of contents should be given for all articles longer than about 60 typed pages, unless they follow the strict format of a taxonomic revision.

9 Acknowledgements

Acknowledgements should be kept to the minimum compatible with the requirements of courtesy. Please give all the initials of the person(s) you are thanking.

10 Literature references

In text

10.1 Literature references in the text should be cited as follows: 'Jones & Smith (1986) stated...', or '...(Jones & Smith 1986)' or (Ellis 1988: 67) when giving a reference simply as authority for a statement. For treatment of literature references in taxonomic papers see 14.

10.2 When more than two authors are involved in the paper, use the name of the first author followed by *et al.*

10.3 When referring to more than one literature reference, they should be arranged chronologically and separated by a semicolon, e.g. (Nixon 1940; Davis 1976; Anon. 1981, 1984).

10.4 Titles of books and names of journals should preferably not be mentioned in the text. If there is good reason for doing so, they should be treated as described in 10.12 and 10.13.

10.5 Personal communications are given only in the text, not in the list of references. Please add the person's full initials to identify the person more positively, e.g. C. Boucher pers. comm.

In References at end of article

10.6 References of the same author are arranged in chronological sequence.

10.7 Where two or more references by the same author are listed in succession, the author's name is repeated with every reference, except in an obituary, where the name of the deceased in the list of publications (not in the references) is replaced by an N-dash.

10.8 All publications referred to in the text, including those mentioned in full in the treatment of correct names in taxonomic papers, but no others, and no personal communications, are listed at the end of the manuscript under the heading References.

10.9 The references are arranged alphabetically according to authors and chronologically under each author, with a, b, c, etc. added to the year, if the author has published more than one work in a year. This sequence is retained when used in the text, irrespective of the chronology.

10.10 If an author has published both on his own and as a senior author with others, the solo publications are listed first and after that, in strict alphabetical sequence, those published with one or more other authors.

10.11 Author names are typed in **capital letters**.

10.12 Titles of journals and of books are written out in full and are italicized as follows: *Transactions of the Linnean Society of London* 5: 171–217, or *Biology and ecology of weeds*: 24.

10.13 Titles of books should be given as in *Taxonomic literature*, edn 2 by Stafleu & Cowan and names of journals as in the latest edition of *World list of scientific periodicals*.

10.14 Examples of references:

Collective book or Flora

BROWN, N.E. 1909. Asclepiadaceae. In W.T. Thiselton-Dyer, *Flora capensis* 6,2: 518–1036. Reeve, London.

CUNNINGHAM, A.B. 1994. Combining skills: participatory approaches in biodiversity conservation. In B.J. Huntley, Botanical diversity in southern Africa. *Strelitzia* 1: 149–167. National Botanical Institute, Pretoria.

Book

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11 Tables (also digital submissions)

11.1 Each table should be presented on a separate sheet and be assigned an Arabic numeral, i.e. the first table mentioned in the text is marked 'Table 1'.

11.2 In the captions of tables the word 'TABLE' is written in capital letters. See recent numbers of *Bothalia* for the format required.

11.3 Avoid vertical lines, if at all possible. Tables can often be reduced in width by interchanging primary horizontal and vertical heads.

12 Figures (also digital submissions)

12.1 **The Publications Section of SANBI prefers to scan original drawings and photographs.** Figures should be planned to fit, after reduction, into a width of either 80, 118 or 165 mm, with a maximum vertical length of 230 mm. Allow space for the caption in the case of figures that will occupy a whole page.

12.2 Line drawings (artwork) **should be in jet-black Indian ink, preferably on fine art paper, 200 gsm, or on draughtsman's film.** Lines should be **clear** enough and letters/symbols large enough to stand reduction. If submitted electronically, provide each drawing as a separate **TIF or JPG file at 600 dots/pixels per inch (dpi/ppi) and a hard copy of the figure.**

12.3 **Graphs and histograms should be submitted as XLS files. Do not submit graphs in colour. If tints are used they should be easily discernible. If the files were generated in other software programmes, export them as TIF or JPG files.**

12.4 Photographs should be of **excellent quality** on glossy paper with clear detail and moderate contrast **so that the figures can be scanned without retouching them electronically,** and they should be the same size as required in the journal. If submitted electronically, provide as a **TIF or JPG file at 300 dpi/ppi and NOT AS A DOC, PDF, EXCEL OR POWERPOINT FILE.** Include a hard copy of good quality.

12.5 Photograph mosaics should be submitted complete, the component photographs mounted neatly on a white flexible card base (can be curved around drum of scanner) leaving a narrow gap of uniform width (2 mm) between each print. Note that grouping photographs of markedly divergent contrast results in poor reproductions. **If submitted electronically, lettering and scale bars must be included.**

12.6 Lettering on photograph mosaics, in capital letters, should be put on a small white disk ± 7 mm in diameter, if the background is dark, and placed in the lower left hand corner of the relevant photo.

12.7 If several illustrations are treated as components of a single composite figure they should be designated by capital letters.

12.8 Note that the word 'Figure' should be written out in full, both in the text and the captions and should begin with a capital 'F' (but see 14.7 for taxonomic papers).

12.9 In the text the figure reference is then written as in the following example: 'The stamens (Figure 4A, B) are...'

12.10 In captions, 'FIGURE' is written in capital letters.

12.11 Scale bars or scale lines should be used on figures, **or appropriate magnifications should be put in the captions.**

12.12 In figures accompanying taxonomic papers, voucher specimens should be given in the relevant caption.

12.13 Figures are numbered consecutively with Arabic numerals in the order they are referred to in the text. These numbers, as well as the author's name and an indication of the top of the figure, must be written in soft pencil on the back of all figures.

12.14 Captions of figures must **not** be pasted under the photograph or drawing and must also **not** be included in any electronic version of the figures.

12.15 Captions for figures should be collected together and typed at the end of the MS and headed *Captions for figures*.

12.16 Authors should indicate in pencil in the text where they would like the figures to appear.

12.17 Authors wishing to have the originals of figures returned must inform the editor in the original covering letter and must mark each original 'To be returned to author'.

12.18 Authors wishing to use illustrations already published elsewhere must obtain written permission before submitting the manuscript and inform the editor of this fact.

12.19 It is strongly recommended that taxonomic articles include dot maps as figures to show the distribution of taxa. **Maps will be reduced to column width (80 mm): the dots and numbers** used must be large enough to stand reduction (recommended size: 5 mm diameter).

12.20 Blank distribution maps of southern Africa, Africa and the world are available from the Bookshop, SANBI Pretoria.

12.21 A dot map PC programme for distribution of taxa in South Africa, called **MAPPIT2** is available for purchase from the Data Section, South African National Biodiversity Institute, Pretoria. **Please submit as a high resolution JPG file at 600 dpi to fit the column width of 80 mm.**

12.22 ArcView GIS maps are acceptable. The layout representing all the appropriate themes (including grid lines) should be **submitted as an encapsulated file (EPS).**

12.23 Colour figures are permitted only if: a) it will clarify the article and b) the cost of reproduction and printing is borne by the author.

12.24 **Magnification of figures in the caption should be given for the size as submitted.**

13 **Text**

13.1 As a rule, authors should use the plant names (but not of all authors of plant names—see 13.6) as listed in PRECIS (National Herbarium **PRE**toria **C**omputerised **I**nformation **S**ystem).

13.2 Names of genera and infrageneric taxa are usually italicized, with the author citation (where relevant; see 13.6) not italicized. Exceptions include names of new taxa in the abstract, correct names given in the synopsis or in paragraphs on species excluded from a given suprageneric group in taxonomic articles; in checklists and in indices, where the position is reversed, correct names are not italicized and synonyms are italicized.

13.3 Names above generic level are not italicized.

13.4 In articles dealing with taxonomy, the complete scientific name of a plant (with author citation) should be given at the first mention in the text. The generic name should be abbreviated to the initial thereafter, except where intervening references to other genera with the same initial could cause confusion (see 16.6).

13.5 In normal text, Latin words are italicized, but in the synopsis of a species, Latin words such as *nom. nud.* and *et al.* are not italicized (see 16.4, 17.9).

13.6 In accordance with Garnock-Jones & Webb (1996) in *Taxon* 45: 285, 286, authors of plant names are not to be added to plant names except in taxonomic papers. Names of authors of plant names should agree with the list published by the Royal Botanic Gardens, Kew, entitled, *Authors of plant names*, edited by R.K. Brummitt & C.E. Powell (1992).

13.7 Modern authors not included in the list should use their full name and initials when publishing new plant names. Other author names not in the list should be in agreement with the recommendations of the Code.

13.8 Names of authors of publications are written out in full, without initials, except in the synonymy in taxonomic articles where they are treated like names of authors of plant names.

13.9 Names of plant collectors are italicized whenever they are linked to the number of a specimen. The collection number is also italicized, e.g. *Acocks 14407*.

13.10 Surnames beginning with 'De', 'Du' or 'Van' begin with a capital letter unless preceded by an initial.

13.11 For measurements use only units of the International System of Units (SI). **In taxonomic papers only mm and m, should be used; in ecological papers cm or m should be used.**

13.12 The use of '±' is preferred to c. or ca (see 17.7).

13.13 Numbers 'one' to 'nine' are spelt out in normal text, and from 10 onwards they are written in Arabic numerals.

13.14 In descriptions of plants, numerals are used throughout. Write 2.0–4.5 (not 2–4.5) and 2.0–4.5 × 6–9. When counting members write 2 or 3 (not 2–3), but 2–4.

13.15 Abbreviations should be used sparingly but consistently. No full stops are placed after abbreviations ending with the last letter of the full word (e.g. edition = edn; editor = ed.); after units of measure; after compass directions; after herbarium designations; after countries, e.g. USA and after well-known institutions, e.g. CSIR.

13.16 Apart from multi-access keys, indented keys should be used with couplets numbered 1a–1b, 2a–2b, etc. (without full stops thereafter).

13.17 Keys consisting of a single couplet have no numbering.

13.18 Manuscripts of keys should be presented as in the following example:

1a Leaves closely arranged on elongated stem; a submerged aquatic with only capitula exserted . . . 1b. *E. setaceum* var. *pumilum*

1b Leaves in basal rosettes; stems suppressed; small marsh plants, ruderals or rarely aquatics:

2a Annuals, small, fast-growing pioneers, dying when habitat dries up; capitula without coarse white setae; receptacles cylindrical:

3a Anthers white . . . 2. *E. cinereum*

3b Anthers black . . . 3. *E. nigrum*

2b Perennials, more robust plants; capitula sparsely to densely covered with short setae:

13.19 Herbarium voucher specimens should be referred to wherever possible, not only in taxonomic articles.

13.20 The word Figure should be written out in full and should begin with a capital F, also in captions where the whole word is in capital letters (see 12.8–12.10).

14 **Species treatment in taxonomic papers**

14.1 The procedure to be followed is illustrated in the example (17.9), which should be referred to, because not all steps are described in full detail.

14.2 The correct name (bold, not italicized) is to be followed by its author citation (italicized) and the full literature reference, with the name of the publication written out in full (not italicized).

14.3 Thereafter all literature references, including those of the synonyms, should only reflect author, page and year of publication, e.g. C.E.Hubb. in Kew Bulletin 15: 307 (1960); Boris et al.: 14 (1966); Boris: 89 (1967); Sims: t. 38 (1977); Sims: 67 (1980).

14.4 The description and the discussion should consist of paragraphs commencing, where possible, with italicized leader words such as *flowering time, etymology, diagnostic characters, distribution and habitat*, **with a colon**

following the leader word and the first word of the sentence beginning with a lower case letter.

14.5 When more than one species of a given genus is dealt with in a paper, the correct name of each species should be prefixed by a sequential number followed by a full stop. Infraspecific taxa are marked with small letters, e.g. 1b., 12c., etc.

14.6 Names of authors are written as in 13.6, irrespective of whether the person in question is cited as the author of a plant name or of a publication.

14.7 The word 'figure' is written as 'fig.', and 't.' is used for both 'plate' and 'tablet' (but see 12.8 for normal text).

14.8 Literature references providing good illustrations of the species in question may be cited in a paragraph commencing with the word Illustrations followed by a colon. This paragraph is given after the last paragraph of the synonymy, see 17.9.

14.9 When new combinations are made, the full literature reference must be given for the basionym, e.g.:

Antimima saturata (*L.Bolus*) *H.E.K. Hartmann*, comb. nov.

Ruschia saturata L.Bolus in Notes on Mesembrianthemum and allied genera, part 2: 122 (1929). *Mesembryanthemum atrocinctum* N.E.Br.: 32 (1930). Type: *Pillans BOL18952* (BOL, holo.–photo!).

15 Citation of specimens

15.1 Type specimen in synopsis: the following should be given (if available): country (if not in RSA), province, grid reference (at least for new taxa), locality as given by original collector, modern equivalent of collecting locality in square brackets (if relevant, e.g. Port Natal [now Durban]), quarter-degree square, date of collection (optional), collector's name and collecting number (both italicized).

15.2 The abbreviation s.n. (*sine numero*) is given after the name of a collector who usually assigned numbers to his collections but did not do so in the specimen in question (see 15.11), or the herbarium number can then be cited with no space between the herbarium and its number e.g. *Marloth SAM691* (see 17.9). The herbaria in which the relevant type(s) are housed are indicated by means of the abbreviations given in the latest edition of *Index Herbariorum*.

15.3 The holotype (holo.) and its location are mentioned first, followed by a semicolon, the other herbaria are arranged alphabetically, separated by commas.

15.4 Authors should indicate by means of an exclamation mark (!) which of the types have been personally examined.

15.5 If only a photograph or microfiche was seen, write as follows: *Anon. 422* (X, holo.–BOL, photo.!).

15.6 Lectotypes or neotypes should be chosen for correct names without a holotype. It is not necessary to lectotypify synonyms.

15.7 When a lectotype or a neotype are newly chosen, this should be indicated by using the phrase 'here designated' (see 17.9). If reference is made to a previously selected lectotype or neotype, the name of the designating author and the literature reference should be given. In cases where no type was cited, and none has subsequently been nominated, this may be stated as 'not designated'.

15.8 In brief papers mentioning only a few species and a few cited specimens the specimens should be arranged according to the grid reference system: Provinces/countries (typed in capitals) should be cited in the following order: Namibia, Botswana, Limpopo (previously Northern Transvaal, Northern Province), North West (previously northeastern Cape and southwestern Transvaal), Gauteng (previously PWV), Mpumalanga (previously Eastern Transvaal), Free State (previously Orange Free State), Swaziland, KwaZulu-Natal (previously Natal), Lesotho, and Northern Cape, Western Cape and Eastern Cape (Figure 1).

15.9 Grid references should be cited in numerical sequence.

15.10 Locality records for specimens should preferably be given to within a quarter-degree square. Records from the same one-degree square are given in alphabetical order, i.e (–AC) precedes (–AD), etc. Records from the same quarter-degree square are arranged alphabetically according to the collectors' names; the quarter-degree references must be repeated for each specimen cited.

15.11 The relevant international code of the herbaria in which a collection was seen should be given in brackets after the collection number; the codes are separated by commas. The following example will explain the procedure:

KWAZULU-NATAL.—2731 (Louwsburg): 16 km E of Nongoma, (–DD), *Pelser 354* (BM, K, PRE); near Dwarsrand, *Van der Merwe 4789* (BOL, M). 2829 (Harrismith): near Groothoek, (–AB), *Smith 234*; Koffiefontein, (–AB), *Taylor 720* (PRE); Cathedral Peak Forest Station, (–CC), *Marriot s.n.* (KMG); Wilgerfontein, *Roux 426*. Grid ref. unknown: Sterkstroom, *Strydom 12* (NBG).

15.12 For records from outside southern Africa authors should use degree squares without names, e.g.:

KENYA.—0136: Nairobi plains beyond race course, *Napier 485*.

15.13 Monographs and revisions: in the case of all major works of this nature it is assumed that the author has investigated the relevant material in all major herbaria and that he has provided the specimens seen with determinavit labels. It is assumed further that the author has submitted distribution maps for all relevant taxa and that the distribution has been described briefly in words in the text. Under the heading 'Vouchers' no more than five specimens should be cited, indicating merely the collector and the collector's number (both italicized). Specimens are alphabetically arranged according to collector's name. If more than one specimen by the same collector is cited, they are arranged numerically and separated by a comma. **A collector's name and the voucher number(s) is separated from the next collector by a semicolon.** The purpose of the cited specimens is not to indicate distribution but to convey the author's concept of the taxon in question.

15.14 The herbaria in which the specimens are housed are indicated by means of the abbreviation given in the latest edition of *Index Herbariorum*. They are given between brackets, arranged alphabetically and separated by commas behind every specimen as in the following example:

Vouchers: *Arnold 64* (PRE); *Fisher 840* (NH, NU, PRE); *Flanagan 831* (GRA, PRE), *840* (NH, PRE); *Marloth 4926* (PRE, STE); *Schelpe 6161, 6163, 6405* (BOL); *Schlechter 4451* (BM, BOL, GRA, K, PRE).

15.15 If long lists of specimens are given, they must be listed together before Acknowledgements under the heading *Specimens examined*. **They are arranged alphabetically by the collector's name and then numerically for each taxon.** The species is indicated in brackets by the number that was assigned to it in the text and any infraspecific taxa by a small letter; **this number follows the specimen number.** If more than one genus is dealt with in a given article, the first species of the first genus mentioned is indicated as 1.1. This is followed by the international herbarium designation. Note that the name of the collector and the collection number are italicized:

Acocks 14724 **(1.13a) BOL, K, P;** ***12497*** **(2.1b) BM, K, PRE.** ***Archer 1507*** **(1.4) BM, G.**

Barker 9738 **(1) NBG;** ***1916*** **(2) NBG;** ***295, 4766, 9478, 9796, 10330*** **(4) NBG;** ***1919*** **(5) BOL, NBG;** ***1917,1923, 1935, 2570, 2606, 2646, 3332, 4198, 4858, 10534, 10801*** **(5) NBG.** ***Burchell 2847*** **(2.8c) MB, K.** ***Burman 2401*** **(3.3) MO, S.** ***B.L. Burtt 789*** **(2.6) B, KMG, STE.**

Esterhuysen 11497 **(1) BOL;** ***1433*** **(5) BOL;** ***71402*** **(5) NBG.**

16 Synonyms

16.1 In a monograph or a revision covering all of southern Africa, all synonyms based on types of southern African origin, or used in southern African literature, should be included.

16.2 Illegitimate names are designated by *nom. illeg.* after the reference, followed by non with the author and date, if there is an earlier homonym.

16.3 Nomina nuda (*nom. nud.*) and invalidly published names are excluded unless there is a special reason to cite them, for example if they have been used in prominent publications.

16.4 In normal text, Latin words are italicized, but in the synopsis of a species Latin words such as *nom. nud., et al.* are not italicized (see 13.5, 17.9).

16.5 Synonyms should be arranged chronologically into groups of nomenclatural synonyms, i.e. synonyms based on the same type, and the groups should be arranged chronologically by basionyms, except for the basionym of the correct name which is dealt with in the paragraph directly after that of the correct name.

16.6 When a generic name is repeated in a given synonymy it should be abbreviated to the initial, except where intervening references to other genera with the same initial could cause confusion (see 13.4).

17 Description and example of species treatment

17.1 Descriptions of all taxa of higher plants should, where possible, follow the sequence: Habit; sexuality; underground parts (if relevant). *Indumentum* (if it can be easily described for the whole plant). *Stems/branches. Bark. Leaves*: arrangement, petiole absent/present, pubescence; blade: shape, size, apex, base, margin; midrib: above/below, texture, colour; petiole; stipules. *Inflorescence*: type, shape, position; bracts/bracteoles, involucral bracts: inner, outer. *Flowers*: shape, sex. *Receptacle. Calyx. Corolla. Disc. Androecium. Gynoecium. Fruit. Seeds. Flowering time. Chromosome number (reference). Conservation status*. Figure number (word written out in full).

17.2 As a rule, shape should be given before measurements.

17.3 In general, if an organ has more than one of the parts being described, use the plural, otherwise use the singular, for example, petals of a flower but blade of a leaf.

17.4 Language must be as concise as possible, using participles instead of verbs.

17.5 Dimension ranges should be cited as in 17.9.

17.6 Care must be exercised in the use of dashes and hyphens. A *hyphen* is a short stroke joining two syllables of a word, e.g. ovate-lanceolate or sea-green, with no space between the letter and the stroke. An *N-dash* (*en*) is a longer stroke commonly used instead of the word 'to' between numerals, '2–5 mm long' (do not use it between words but rather use the word 'to', e.g. 'ovate to lanceolate'; it is produced by typing three hyphens with spaces in between, or in MS Word the code is alt + 0150. An *M-dash* (*em*) is a stroke longer than an N-dash and is used variously, e.g. in front of a subspecific epithet instead of the full species name; it is produced by typing two hyphens with spaces in between, or in MSWord the code is alt + 0151. See also 2.10–2.12.

17.7 The use of '±' is preferred to c. or ca when describing shape, measurements and dimensions (see 13.12).

17.8 The decimal point replaces the comma in all units of measurement, e.g. leaves 1.0–1.5 mm long.

17.9 Example:

1. **Englerophytum magalismontanum** (*Sond.*) *T.D.Penn.*, The genera of Sapotaceae: 252 (1991). Type: Gauteng, Magaliesberg, *Zeyher 1849* (S, holo.–BOL, photo.!).

Bequaertiodendron magalismontanum (Sond.) Heine & Hemsl.: 307 (1960); Codd: 72 (1964); Elsdon: 75 (1980).

Chrysophyllum magalismontanum Sond.: 721 (1850); Harv.: 812 (1867); Engl.: 434 (1904); Bottmar: 34 (1919). *Zeyherella magalismontana* (Sond.) Aubrév. & Pellegr.: 105 (1958); Justin: 97 (1973).

Chrysophyllum argyrophyllum Hiern: 721 (1850); Engl.: 43 (1904). *Boivinella argyrophylla* (Hiern) Aubrév. & Pellegr.: 37 (1958); Justin et al.: 98 (1973). Types: Angola, *Welwitsch 4828* (BM!, lecto., here designated; PRE!); Angola, *Welwitsch s.n.* (BM!).

Chrysophyllum wilmsii Engl.: 4, t. 16 (1904); Masonet: 77 (1923); Woodson: 244 (1937). *Boivinella wilmsii* (Engl.) Aubrév. & Pellegr.: 39 (1958); Justin: 99 (1973). Type: without locality and collector [B, holo.†; K!, P!, lecto., designated by Aubrév. & Pellegr.: 38 (1958), PRE!, S!, W!, Z!].

Bequaertiodendron fruticosa De Wild.: 37 (1923), non Bonpl.: 590 (1823); D.Bakker: 167 (1929); H.Fr.: 302 (1938); Davy: 640 (1954);

Breytenbach: 117 (1959); Clausen: 720 (1968); Palmer: 34 (1969). Type: Mpumalanga, Tzaneen Dist., *Granville in Herb. Pillans K48625* (K, holo.!; G!, P!, PRE!, S!).

B. fragrans auct. non Oldemann: Glover: 149, t. 19 (1915); Henkel: 226 (1934); Stapelton: 6 (1954).

Illustrations: Harv.: 812 (1867); Henkel: t. 84 (1934?); Codd: 73 (1964); Palmer: 35 (1969).

Woody perennial; main branches up to 0.4 m long, erect or decumbent, grey woolly-felted, leafy. *Leaves* linear to oblanceolate, 3–10(–23) × 1.0–1.5(–4.0) mm, obtuse, base broad, half-clasping. *Heads* heterogamous, campanulate, 7–8 × 5 mm, solitary, sessile at tip of axillary shoots; involucral bracts in 5 or 6 series, inner exceeding flowers, tips subopaque, white, very acute. *Receptacle* nearly smooth. *Flowers* ± 23–30, 7–11 male, 16–21 bisexual, yellow, tipped pink. *Achenes* ± 0.75 mm long, elliptic. *Pappus* bristles very many, equalling corolla, scabridulous. *Flowering time*: September. *Chromosome number*: 2n = 22. Figure 23B.

18 New taxa

18.1 The name of a new taxon must be accompanied by at least a Latin diagnosis. Authors should not provide full-length Latin descriptions unless they have the required expertise in Latin at their disposal.

18.2 It is recommended that descriptions of new taxa be accompanied by a good illustration, **preferably a line drawing, or a photograph (second choice)** and a distribution map.

18.3 Example:

109. **Helichrysum jubilatum** *Hilliard*, sp. nov., *H. alsinoidei* DC. affinis, sed foliis ellipticis (nec spatulatis), inflorescentiis compositis a foliis non circumcinctis, floribus femineis numero quasi dimidium hermaphroditorum aequantibus (nec capitulis homogamis vel floribus femineis 1–3 tantum) distinguitur.

Herba annua e basi ramosa; caules erecti vel decumbentes, 100–250 mm longi, tenuiter albo-lanati, remote foliati. *Folia* plerumque 8–30 × 5–15 mm, sub capitulis minora, elliptica vel oblanceolata, obtusa vel acuta, mucronata, basi semi-amplexicauli, utrinque canolanato- arachnoidea. *Capitula* heterogama, campanulata, 3.5– 4.0 × 2.5 mm, pro parte maxima in paniculas cymosas terminales aggregata; capitula subterminalia interdum solitaria vel 2 vel 3 ad apices ramulorum nudorum ad 30 mm longorum. *Bracteae involucrales* 5-seriatae, gradatae, exteriores pellucidae, pallide stramineae, dorso lanatae, seriebus duabus interioribus subaequalibus et flores quasi aequantibus, apicibus obtusis opacis niveis vix radiantibus. *Receptaculum* fere laeve. *Flores* ± 35–41. *Achenia* 0.75 mm longa, pilis myxogenis praedita. *Pappi* setae multae, corollam aequantes, apicibus scabridis, basibus non cohaerentibus.

TYPE.—Northern Cape, 2817 (Vioolsdrif): Richtersveld, (–CC), ± 5 miles E of Lekkersing on road to Stinkfontein, kloof in hill south of road, annual, disc whitish, 7-11-1962, *Nordenstam 1823* (S, holo.; E, NH, PRE).

19 New provinces of South Africa (Oct. 1996)

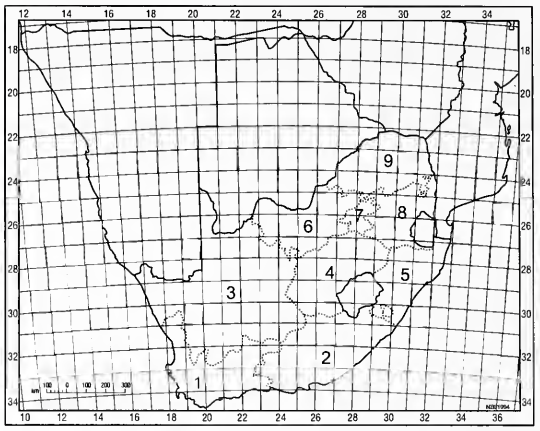

FIGURE 1.—1, Western Cape; 2, Eastern Cape; 3, Northern Cape; 4, Free State (previously Orange Free State); 5, KwaZulu-Natal (previously Natal); 6, North-West (previously northeastern Cape and southwestern Transvaal); 7, Gauteng (previously PWV); 8, Mpumalanga (previously Eastern Transvaal); 9, Limpopo (previously Northern Transvaal, Northern Province).

20 Proofs

Only page proofs are normally sent to authors. They should be corrected in red ink and be returned to the editor **as soon as possible**. Do not add any new information.

21 Reprints

Authors receive 20 reprints free. If there is more than one author, this number will have to be shared between them. A pdf file of the article is available on request, bearing in mind that it is for private use only, the copyright protecting it from being used in another publication/journal.

22 Documents consulted

Guides to authors of the following publications were made use of in the compilation of the present guide: *Annals of the Missouri Botanic Garden, Botanical Journal of the Linnean Society, Flora of Australia, Smithsonian Contributions to Botany, South African Journal of Botany* (including instructions to authors of taxonomic papers), *South African Journal of Science*.

23 Address of editor

Manuscripts should be submitted to: The Editor, *Bothalia*, South African National Biodiversity Institute, Private Bag X101, Pretoria 0001.

24 *FSA* contributions

24.1 Figures and text must conform to *Bothalia* format.

24.2 These articles will be considered as a full contribution to the *Flora of southern Africa* and will be listed as published in the '*Plan of Flora of southern Africa*', which appears in all issues of the *FSA* series.

25 Place names

Ensure that local place names are correct. If in doubt, consult the Internet at http://sagns.dac.gov.za/searchplacenamedatabase.asp

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BOTHALIA

Volume 37,2 Oct. 2007

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ISSN 006 8241